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RMRS Rocky Mountain Remediation Services, L.L.C.
. . . protecting the environment

INTEROFFICE MEMORANDUM

DATE: October 16, 1995

TO: Distribution

FROM: R. Roberts, RMRS Remediation Services, Bldg. T893B, X4869

SUBJECT: REVIEW OF THE DRAFT 903 PAD AND WINDBLOWN SOILS INTERIM MEASURE/INTERIM REMEDIAL ACTION (IM/IRA) – RR-005-95

Action: Review and comment on Draft IM/IRA.

Enclosed is the Draft Interim Measure/Interim Remedial Action for the 903 Pad and Windblown Soils for your review and comment. Please submit comments to me by October 27, 1995. A comment review meeting is scheduled for 8 AM on October 27 in Building T893B to review any significant concerns.

If you have any questions of comments, please contact me.

Enclosure:
As Stated

cc:
M. C. Broussard
J. Dunlop
C. S. Evans
L. Guinn
J. K. Hopkins
G. R. Konwinski
J. D. Krause
J. E. Law
R. S. Luker
A. L. Primrose
C. Spittle
W. R. Sproles
D. E. Steffen
ER Records (2)
RMRS Records

1/144

BZ-A-000378

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INTERIM MEASURE/INTERIM REMEDIAL ACTION DECISION DOCUMENT

Rocky Flats Environmental Technology Site
903 Pad and Windblown Soils
(Operable Unit No. 2)

ROCKY MOUNTAIN REMEDIAL SERVICES
P.O. Box 464
Golden, Colorado
80402-0464

Prepared For:

United States Department of Energy
Rocky Flats Environmental Technology Site
Golden, Colorado

October 1995

2

DRAFT

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EXECUTIVE SUMMARY

This decision document was prepared to provide an expedited remedial action strategy for the 903 Pad and Windblown Soils located in Operable Unit No. 2 (OU2) at the Rocky Flats Environmental Technology Site (RFETS), formerly the Rocky Flats Plant (RFP), in Jefferson County, Colorado. These recommendations are presented as an interim measure/interim remedial action (IM/IRA). This decision document is submitted by the U.S. Department of Energy (DOE) to request comment and approval from the public, the U.S. Environmental Protection Agency (EPA) Region VIII, and the Colorado Department of Public Health and the Environment (CDPHE), formerly the Colorado Department of Health (CDH). Under the terms of the Interagency Agreement (IAG) dated January 22, 1991, both the EPA and CDPHE were designated as joint lead regulatory agencies for OU2.

The Individual Hazardous Substance Sites (IHSS) of primary concern are the 903 Drum Storage Site (IHSS No. 112) and the 903 Pad Lip Area (IHSS No. 155). The DOE also intends to address all surficial soils in OU2 in this IM/IRA including IHSS No. 183, the Gas Detoxification Site, IHSSs 216.3 East Spray Field South, and IHSS No. 216.2 East Spray Field Center. The implementation of this IM/IRA will expedite the final remediation of these IHSSs and prevent the potential further migration of contamination

Based on the previous Resource Conservation and Recovery Act (RCRA) facility investigation/remedial investigation (RFI/RI), various IM/IRA remedial alternatives have been identified and evaluated to:

- Remediate the OU2 sources of contamination to protect human health and the environment from unacceptable exposure to contaminants via direct contact, inhalation, or ingestion pathways, and to eliminate migration pathways to surface water.
- Provide surface soil remediation that will be compatible with the final corrective action decision/record of decision for OU2.

Remediation alternatives that were potentially applicable to the remediation of OU2 are identified and evaluated in this IM/IRA Decision Document. These alternatives present a wide range of actions and include:

- no further action,
- institutional control closure of the units leaving contaminated materials onsite under an enhanced vegetative cover,

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- excavation of all contaminated materials for onsite disposal, and

- excavation of all contaminated materials for *ex situ* treatment and return to OU2.

Based on the results of the detailed analysis of the IM/IRA remedial alternatives, the DOE recommends that contaminated surface soils beneath the 903 Pad Drum Storage Site and within a 3.1 acre area adjacent to the 903 Pad, which have concentrations of radionuclide contaminants above a level that would result in a 15 millirem annual radiation dose, be excavated and dispositioned in the site-wide waste management facility.

The excavation and disposal alternative will eliminate the potential exposure to contaminated surface soils via direct contact, ingestion and inhalation due to the removal of the majority of the contamination source. The proposed alternative is a final remedy for the OU2 surface soils which is the most cost effective alternative based on a present worth analysis. The Excavation and Disposal alternative is also consistent with the DOE goal of centrally locating contaminated media in a controlled and monitored site-wide waste management facility rather than having numerous small OU specific closure/remediation areas.

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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
ALARA	As low as reasonably achievable
Am	americium
AOC	area of concern
ARAR	applicable or relevant and appropriate requirements
ATTIC	Alternative Treatment Technology Information Center
bgs	below ground surface
BRA	baseline risk assessment
BSL	background screening level
C/RAO	corrective/remedial action objective
CDH	Colorado Department of Health
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	curie
cm	centimeter
CMS/FS	corrective measures study/feasibility study
COC	contaminant of concern
cpm	counts per minute
Cr	chromium
CR	cancer risk
CT	central tendency
DAA	detailed analysis of alternatives
DCG	derived concentration guideline
DOE	U.S. Department of Energy
DOT	(U.S. or Colorado) Department of Transportation
dpm	disintegrations per minute
EP	extraction procedure
EPA	U.S. Environmental Protection Agency
ERA	environmental risk assessment
ET	evapotranspiration
FR	Federal Register
FS	feasibility study
g	gram
GRA	general response actions
HASL	health and safety laboratory
HEPA	high-efficiency particulate air
Hg	mercury
HHRA	human health risk assessment
HI	hazard index
HQ	noncancer hazard quotient
IA	industrial area

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ACRONYMS AND ABBREVIATIONS (Continued)

IAG	Interagency Agreement
IHSS	individual hazardous substance sites
IM/IRA	interim measure/interim remedial action
IROD	interim record of decision
kg	kilogram
L	liter
mg	milligram
μcurie	microcurie
μg	micrograms
μmhos	micromhos
mm	millimeter
mrem	millirem
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NFA	no further action
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
O&M	operation and maintenance
OSHA	Occupational Safety and Health Administration (or Act)
OU	operable unit
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PCB	polychlorinated biphenyl
PCOC	potential contaminant of concern
PM_{10}	particulate mater less than 10 microns in diameter
PPE	personal protective equipment
ppm	parts per million
Pu	plutonium
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA facility investigation/remedial investigation
RFLII	Rocky Flats Local Impact Initiative
RFP	Rocky Flats Plant
RI	remedial investigation
RME	reasonable maximum exposure
RREL	Risk Reduction Environmental Laboratory
SF	cancer slope factor
SVOC	semi-volatile organic compound
TBC	to be considered

ACRONYMS AND ABBREVIATIONS (Continued)

TBD	to be determined
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
U	uranium
UCL	upper confidence limit
UHSU	upper hydrostratigraphic unit
USC	United States Code
VISTT	Vendor Information System for Innovative Treatment Technologies
VOC	volatile organic compound
WAC	waste acceptance criteria

PART I
DECLARATION

I.1 PROBLEM DEFINITION, OBJECTIVES, AND PURPOSE

This decision document was prepared to provide an expedited remedial action strategy for the 903 Pad and Windblown Soils located in Operable Unit No. 2 (OU2) at the Rocky Flats Environmental Technology Site (RFETS), formerly the Rocky Flats Plant (RFP), in Jefferson County, Colorado. These recommendations are presented as an interim measure/interim remedial action (IM/IRA). This decision document is submitted by the U.S. Department of Energy (DOE) to request comment and approval from the public, the U.S. Environmental Protection Agency (EPA) Region VIII, and the Colorado Department of Public Health and the Environment (CDPHE), formerly the Colorado Department of Health (CDH). Under the terms of the Interagency Agreement (IAG) dated January 22, 1991, both the EPA and CDPHE were designated as joint lead regulatory agencies for OU2.

The DOE had initiated a corrective measures study/feasibility study (CMS/FS) for OU2 in accordance with the IAG. This effort included the development of corrective/remedial action objectives (C/RAOs), the screening of process options and remedial technologies, and the development of remedial alternatives. During development of the CMS/FS, the OU2 subsurface source areas were determined to be candidates for accelerated actions and have since been managed as separate actions. Remediation of OU2 groundwater contamination has been proposed to be conducted under a site-wide cleanup action as part of the site-wide assessment/remediation program.

In the spring of 1995, an unusually heavy rainfall occurred, which contributed to the DOE now proposing that the 903 Pad and Windblown Soils (OU2 surface soils) be remediated through an expedited IM/IRA program. In the spring of 1995, the OU2 soils became saturated with water resulting from a series of heavy precipitation events. A 15-year rainfall event on May 17, 1995 resulted in sheet flow of surface water runoff across the saturated ground surface. This overland flow resulted in soil erosion in areas surrounding the 903 Pad, and washed out a culvert in the 903 Pad Lip Area. The surface runoff water contacted soils contaminated with plutonium-239/240 (Pu-239/240) and americium-241 (Am-241) and apparently transported them down the hillside. This was considered a significant event because previous studies and sampling efforts had not identified surface water runoff as a contaminant transport mechanism.

The DOE proposes this IM/IRA to remediate contaminated surface soils which pose a risk to human health and the environment and to repair the damage caused by surface water erosion. The IAG requires that an appropriate range of C/RAOs be established to screen and evaluate potential remedial alternatives. At a minimum, the C/RAOs are to be developed for the protection of human health and the environment. These objectives should specify the contaminants and media of interest, exposure pathways, and acceptable contamination levels or ranges of levels for each exposure route.

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Technical Memorandum No. 2 (DOE, 1995c) for the OU 2 CMS/FS identified the following C/RAOs for surface soil. These C/RAOs shall be applied to the 903 Pad and Windblown Soils IM/IRA:

- Remediate contaminated surface soil to non-zero chemical-specific applicable or relevant and appropriate requirements (ARARs) or to-be-considered (TBCs) criteria, as appropriate; and

- In the absence of ARARs/TBCs, remediate contaminated surface soils so that they are within an acceptable risk range (excess cancer risk greater than 10^{-4} to 10^{-6} or a hazard index of greater than one for noncarcinogens), considering the reasonable maximum exposure scenario.

The general programmatic objectives of this IM/IRA are to:

- Eliminate or minimize unacceptable airborne dispersion of contamination;

- Eliminate or minimize surface water runoff dispersion of contamination;

- Eliminate biological transport of contamination;

- Develop a corrective measure to repair any erosional damage that may have been caused by the spring 1995 precipitation event, and to prevent future erosional damage;

- Be consistent with the final, long-term remedy for OU2, to the extent practicable;

- Comply with ARARs/TBCs and/or risk-based remediation standards for surface soils;

- Eliminate or minimize the potential spread of contaminants during construction;

- Minimize the generation of new waste requiring treatment, storage, and/or disposal;

- Propose a remedial alternative that would be acceptable to the community and approved by the regulatory agencies; and

- Implement the accepted remedial alternative within congressionally approved fiscal constraints.

The primary individual hazardous substance sites (IHSS) of concern in this IM/IRA are the 903 Pad Drum Storage Site (IHSS 112), and the 903 Pad Lip Area (IHSS 155). The DOE also intends to address all surficial soils previously in OU2 in this IM/IRA including: 1) IHSS 183, the Gas Detoxification Site, 2) IHSSs 216.3, East Spray Field South, and 3) IHSS No. 216.2, East Spray Field Center.

Implementation of this IM/IRA will expedite the final remediation of these IHSSs and prevent the potential further migration of contamination as a result of future natural events. The current plan for the remediation of all of the IHSSs previously within OU2 is displayed in Table I.1-1. Those IHSSs listed under the site-wide assessment/remediation program will be addressed under separate cover.

Part I of this IM/IRA decision document defines the problem associated with the 903 Pad and Windblown Soils and summarizes the results of the Resource Conservation and Recovery Act (RCRA) facility investigation/remedial investigation (RFI/RI) and human health risk assessment (HHRA). Part II of this document presents the remedial alternatives that were considered and the action-specific ARARs and TBC implementation strategy, and design criteria for the proposed alternative.

This proposed IM/IRA will be submitted to the EPA Region VIII and the CDPHE for review and comment. The DOE will open a public comment period for a minimum of 60 days. In addition, the DOE will hold a public hearing if requested by the public, EPA, or CDPHE.

At the conclusion of the public comment period, DOE will prepare a responsiveness summary for EPA and CDPHE review and approval. The responsiveness summary will be provided as Part III of the final IM/IRA decision document. The IM/IRA decision document will become the Record of Decision (ROD) for RFETS.

Implementation of the remedial action will commence upon EPA and CDPHE approval of the responsiveness summary and the final IM/IRA decision document (contingent on funding availability). As required by the IAG, DOE will make the EPA- and CDPHE-approved IM/IRA decision document available to all interested parties at least 10 days prior to the commencement of any remedial actions. Remedial action is anticipated to begin in FY97.

I.2 SITE OVERVIEW

RFETS is a government-owned, contractor-operated facility formerly used for the fabrication of special nuclear materials for national defense. The 6,550-acre site is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver. The cities of Boulder, Broomfield, Westminster, Golden, and Arvada are located less than 10 miles to the northwest, northeast, east, south, and southeast, respectively. Figure I.2-1 presents the location of OU2 at the RFETS, and in relation to the State of Colorado.

Centrally situated within the RFETS boundary is a 400-acre security area that contains the buildings and other structures formerly used to support the weapon component fabrication operations. The remaining 6,150 acres consist of undeveloped land used as a buffer zone to

TABLE I.1-1
CURRENT PLAN FOR REMEDIATION OF OU2 IHSSs

IHSS	Interim Measures/ Interim Response Action[a/]	Site-Wide Assessment/ Remediation Program
903 Pad Drum Storage Site (112)	X	
903 Pad Lip Area (155)	X	
East Spray Fields (216.2)	X	
East Spray Field (216.3)	X	
Gas Detoxification Site (183)	X	
Mound Site (113)		X
Oil Burn Pit No.2 Site (153)		X
Pallet Burn Site (154)		X
Reactive Metal Destruction Site (140)		X
Trench T-1 (108)		X
Trench T-2 (109)		X
Trench T-3 (110)		X
Trench T-4 (111.1)		X
Trench T-5 (111.2)		X
Trench T-6 (111.3)		X
Trench T-7 (111.4)		X
Trench T-8 (111.5)		X
Trench T-9 (111.6)		X
Trench T-10 (111.7)		X
Trench T-11 (111.8)		X
Trench T-12		X
Trench T-13		X
UHSU Groundwater		X

a/ - Included in this IM/IRA decision document.

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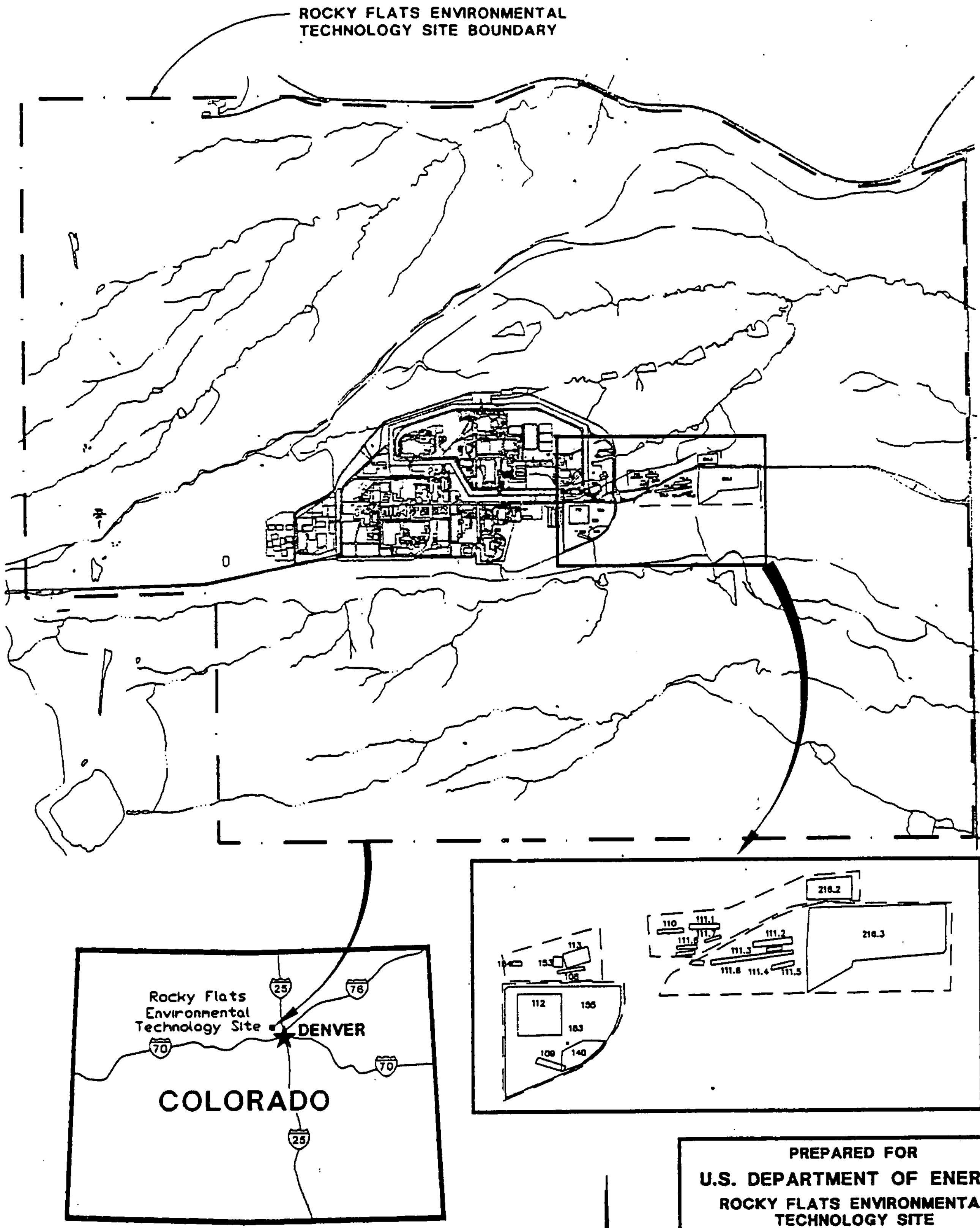

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U.S. DEPARTMENT OF ENERGY

ROCKY FLATS ENVIRONMENTAL
TECHNOLOGY SITE
GOLDEN, COLORADO

Figure I.2-1

Operable Unit No. 2
Interim Measure/Interim Remedial Action
Location Map

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restrict access to the operations area. Fabrication operations began at the RFETS in 1951 and ceased in 1991 when RFETS mission was changed to environmental restoration and waste management. The fabrication operations resulted in the generation of liquid and solid wastes containing radioactive and hazardous constituents managed in various waste processing units.

OU 2 includes areas east and southeast of the security area. These areas are administratively controlled. Contained in OU2 are multiple IHSSs, including a former drum storage area, material burn surface areas, spray fields, and disposal trenches. Figure I.2-2 shows a map of the IHSSs previously within OU2. This IM/IRA addresses the surface soils within this area and the associated IHSSs described earlier.

I.3 OU2 SURFACE SOIL, INCLUDING NATURE AND EXTENT OF CONTAMINATION

The following sections describe the nature and extent of the contamination associated with the 903 Pad and Windblown Soils. This information is presented by IHSS where applicable.

I.3.1 903 Pad Drum Storage Site (IHSS 112)

The 903 Pad Drum Storage Site, also referred to as the 903 Pad, is located southeast of the RFETS Industrial Area (IA). Drums were stored at this site from the summer of 1958 to January 1967 that contained radioactively contaminated oils and solvents. Drum storage at the 903 Pad occurred over the entire pad area, with maximum storage in April 1965, based on historical photographs. A description by Catkins (1970) of the drums that were stored at the drum storage site follows:

> Most of the drums transferred to the field were nominal 55-gallon drums, but a significant number were 30-gallon drums. Not all were completely full. Approximately three-fourths of the drums were plutonium contaminated, while most of the balance contained uranium isotopes. Of those containing plutonium, most were lathe coolant consisting of a straight-chain hydrocarbon mineral oil (Shell Vitrea) and carbon tetrachloride in varying proportions. Other liquids were contained, including hydraulic oils, vacuum pump oil, trichloroethylene, perchloroethylene, silicone oils, acetone still bottoms, etc. Originally, contents of the drums were indicated on the outside, but these markings were made illegible through weathering and no other records were kept of the contents. Oil leakage was recognized, and in 1959 (or possibly earlier) ethanolamine was added to the oil to reduce the corrosion rate of the steel drums.

Drum leakage was noted at the 903 Pad Drum Storage Site as early as 1959. Initial corrective action consisted of transferring the contents of leaking drums to new drums and installing a fence around the area to restrict access (Dow Chemical, 1971). Approximately 420 drums showed evidence of leakage, and of these, an estimated 50 leaked their entire contents (Dow Chemical, 1971).

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An estimated 5,000 gallons of liquid (Freiberg, 1970) containing 86 grams (g) of plutonium (5.3 curies [Ci]) leaked into the soil (Dow Chemical, 1971).

A heavy rainstorm in August 1967 caused contaminants to migrate into a ditch south and southeast of the drum storage site (Dow Chemical, 1971). During an investigation conducted by the Atomic Energy Commission (AEC) Health and Safety Laboratory (HASL), it was estimated that as much as 125 g (total) of Pu-239 were released from the 903 Pad Drum Storage Site and redistributed by winds (Krey and Hardy, 1970).

During radiological monitoring of the 903 Pad in 1971, four "hot spots" were identified. This led to the removal of 31 kilograms (kg) of depleted uranium and up to 10.3 milligrams (mg) of plutonium from beneath the asphalt cover. During sampling activities associated with this removal action, an oil layer, contaminated with depleted uranium, was discovered in two separate boreholes at depths of 45.7 and 76.2 centimeters (cm) (18 inches and 30 inches). A clay layer was noted beneath the contaminated zone. At that time, no contamination was found below the clay layer, and it was believed that the layer served as a natural barrier to downward migration of contaminants. However, the draft OU2 RFI/RI identified radiological contamination at decreasing concentrations from 0.6 to 6 meters (2 to 20 feet) below ground surface (bgs).

I.3.2 903 Pad Lip Area (IHSS 155)

During drum storage, removal, and cleanup activities associated with the 903 Pad Drum Storage Site, wind and rain redistributed plutonium beyond the 903 Pad. Contamination was primarily to the south and east, extending to the southeast perimeter road. An estimated 16 g of Pu-239/240 were redistributed beyond the asphalt pad, in an area exceeding 2,000 acres. The most contaminated area, called the 903 Pad Lip Area, was located immediately adjacent to the 903 Pad to the south and southeast (See Figure 1.2-2).

Contaminated soil, identified in the past though radiological monitoring, has been excavated from the 903 Pad Lip Area. In 1973, an aerial radiological survey detected radioactive concentrations in the 903 Pad Lip Area that were greater than 2,000 counts per minute (cpm). In 1975, eight 55-gallon drums of soil were removed from this 903 Pad Lip Area. Ambient air monitoring during excavation did not detect plutonium in concentrations that would endanger onsite workers, the public, or the environment.

In 1976, approximately 113.3 cubic meters (4,000 cubic feet) of soil were removed from within the 903 Pad Lip Area. Soil removal activities were conducted again in 1978 when an estimated 4,000 square meters (43,000 square feet) of soil that exceeded 2,000 cpm were removed to a depth of approximately 3.5 cm (1.4 in.). All waste was packaged and shipped to the Nevada Test Site (DOE, 1992). The excavated area was backfilled and revegetated.

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Soil cleanup was performed along the eastern edge of the 903 Pad Lip Area in 1984 (Setlock, 1984). A total of 214 tri-wall pallets of contaminated soil were removed from the area. The soil disposal location was not provided by Setlock (1984). The excavated area was covered with clean topsoil and vegetated.

Although several removal actions have been conducted in the 903 Pad Lip Area, recent sampling has detected the presence of elevated concentrations of Pu-239/240 and Am-241. The vertical profile of actinides in the region follows a unique profile with depth. In general, the highest activity is found in the top 3 cm (1.2 inches), followed by a significant decrease between 6 and 9 cm (2.4 and 3.4 inches). An increase in actinide activity is found at the original surface level beneath the revegetated fill level. The increase of actinide activity in the top 3 cm (1.2 inches) of fill material cannot be explained by the previous historical wind dispersion transport from the 903 Pad Drum Storage Site.

Based on the site history and other information, burrowing animals, ant colonies, and earthworms have been observed at the 903 Pad Lip Area and are potential transport mechanisms for residual contamination that remains in the 903 Pad Lip Area. Geological features of the site, such as lateral discontinuities and macroporosity, could also contribute to the redistribution of contaminants (Litaor *et al*, 1994).

I.3.3 Remaining OU2 Surface Soils

The remaining surface soil contamination is in:

- IHSSs 183, 216.2, 216.3.
- Areas primarily to the east and southeast of the 903 Pad Lip Area (buffer zone east of the '03 Pad and Lip Area).
- Operable Unit No. 1 (OU1) surface soils contiguous to OU2, which are contaminated with low-levels of plutonium. OU1 surface soil in this area is believed to have been contaminated by wind transport from the 903 Pad Drum Storage Site.

The Gas Detoxification Site, IHSS 183, includes Building 952 which was constructed as a Toxic Gas Storage Building. This building is located within the IHSS 155 boundary, and the contents of the building have previously been determined to have been contaminated by contaminants present in IHSSs 112 and 155 (DOE, 1992). There are no historical reports of surface soil contamination as a result of operations in this building, and the RFI/RI did not identify any other contaminants within this area.

The East Sprays Fields, IHSSs 261.2 and 261.3, were used to reduce water levels in Pond B-3, which receives sanitary wastewater from the industrial area. Pond B-3 water was sprayed over the IHSSs, resulting in saturation and, in some instances, overland flow. A chromic acid spill in Building

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444 resulted in the inadvertent discharge of an estimated 4.7 pounds of chromium to Pond B-3 which was subsequently sprayed on the East Spray Fields. Following the chromium release, 34 samples were collected from spray field surface soils. Remediation of surface soils is not necessary due to elevated surface soil concentrations of chromium.

Contamination in the remaining surface soil area is attributed primarily to wind dispersion from the 903 Pad Drum Storage Site. Plutonium contamination also potentially originated from historical fires and stack effluent of the production facilities. The RFI/RI data indicate a large variability in Pu-239/240 and Am-241 activity near the source area between the samples taken using CDPHE sampling protocol and the RFETS sampling protocol (DOE, 1995b). This variability probably occurred due to wind erosion, some solubility and leachability, and the "hot particle" phenomenon. As defined by Winsor and Whicker (1979), a "hot particle" has an activity above 450 picoCuries per gram (pCi/g), and it is usually an agglomeration of numerous host soil grains and plutonium oxides. Studies conducted at the RFETS indicated a significant variation in the sizes and spatial distributions of the plutonium particles in the soil. Therefore, a large variability in a short sampling interval is not surprising. Additionally, the RFETS soil sampling techniques involve collecting large quantities (up to 5 kg), of which only a representative sample is processed and analyzed. This could explain the variation in actinide activities.

Other possible causes of the large variability in actinide activity across the remediation area include prior vehicle and construction disturbance and past cleanup practices. A 1994 aerial photograph taken by the Radiological Assessment Group showed that large vehicular and/or construction disturbances occurred in at least one sampling plot. Based on the required sampling protocol involving 5 to 10 subsamples in the middle of the plot, samples could have been taken in a highly disturbed location which was not representative of the original contaminant loading.

I.4 SITE CHARACTERISTICS AND ENVIRONMENTAL SETTING

Appendix A describes the site characteristics and environmental setting of the 903 Pad and Windblown Soils Area. These aspects are important in analyzing the risks to human health and the environment as well as in designing the preferred alternative. Appendix A provides detailed information with respect to:

- Demography and land use;
- Topography and geomorphology;
- Climatology, meteorology, and air quality;
- Site and local surface water hydrology;
- Site and local soils;
- Regional and local geology;
- Regional and local hydrogeology;
- Ecology; and
- Social and economic resources.

I.5 RFI/RI, ENVIRONMENTAL RISK ASSESSMENT, HUMAN HEALTH RISK ASSESSMENT, AND REMEDIATION GOALS

This section provides a summary description of the surface soil and surface water characterization results, results of the environmental risk assessment (ERA), results of the human health risk assessment (HHRA), calculation of remediation goals, and a screening of surface soil COCs. The 903 Pad and Windblown Soils IM/IRA will address risks associated with airborne contamination, biota transport, and surface water erosion.

I.5.1 Summary of RFI/RI Surface Soil Results

Surface soil samples were collected across an area of approximately 800 acres, as shown on Figure I.5-1. The surface soil plots were 2.5 and 10 acres in size. Surface soil samples were collected in 1991 via the CDPHE sampling methodology. Using the CDPHE sampling method, 25 equally spaced and uniformly distributed subsamples were composited within each 2.5- or 10-acre plot. This method was employed to evaluate the spatial extent of contamination. In 1992, the plots were resampled via the RFETS sampling method. Using the RFETS sampling method, ten subsamples were collected from the corners and center of two 1-meter squares spaced 1 meter apart at the center of each 2.5- and 10-acre plot. The surface soil samples were collected from a depth of 5 cm using the RFETS sampling method and 6 millimeters (mm) using the CDPHE sampling method.

Additional surficial soil samples were collected in 1993 through an approved field sampling plan in support of the HHRA. In determining the sampling locations, the OU2 area was divided into 9,126 contiguous 50-foot by 100-foot plots. Forty plots were systematically selected for sampling. Six of the 40 plots were biased plot locations specifically selected for sampling because they were located within IHSSs potentially containing contaminated surface soils (based on a review of the activities conducted in OU2). The remaining 34 plots were evenly spaced throughout the OU2 area. One composite soil sample was taken from each of the plots using a modification of the RFETS sampling method. Ten subsamples were collected and composited from the corners and center of two 1-meter squares, placed 1 meter apart.

Samples collected using the CDPHE sampling method were analyzed for uranium, plutonium, and americium isotopes. Samples collected using the RFETS sampling method were analyzed for plutonium and americium isotopes. The samples collected for the HHRA were analyzed for semi-volatile organic compounds (SVOCs), pesticides and polychlorinated biphenyls (PCBs), metals, inorganic constituents, and radionuclides. The results of the analysis for constituents that were determined to be potential contaminants of concern (PCOCs) are presented in Table I.5-1. Additional information regarding these results can be found in the Phase II RFI/RI Report for OU2 (DOE, 1995b).

TABLE I.5-1
ANALYTICAL RESULTS FOR PCOCs IN SURFACE SOILS IN OU2

Analyte	Background Screening Level(s)	Number of Samples	Number of Detections[a]	Percent Detections	Mean Concentration or Activity[b]
Semivolatile Organic Compounds (µg/kg)[c]					
Benzo(a)anthracene	NA[d]	42	8	19.0%	87
Benzo(a)pyrene	NA	42	9	21.4%	93
Benzo(b)fluoranthene	NA	42	9	21.4%	134
Benzo(g,h,i)perylene	NA	42	1	2.4%	45
Benzo(k)fluoranthene	NA	42	2	4.8%	73
Benzoic acid	NA	42	39	92.9%	244
Bis(2-Ethylhexyl)phthalate	NA	42	9	21.4%	121
Chrysene	NA	42	12	28.6%	97
Di-n-Butylphthalate	NA	42	1	2.4%	1000
Fluoranthene	NA	42	20	47.6%	153
Indeno(1,2,3-cd)pyrene	NA	42	2	4.8%	64
Phenanthrene	NA	42	13	31.0%	89
Pyrene	NA	42	24	57.1%	131
Pesticides and PCBs(µg/kg)[c]					
4,4'-DDT	NA	42	1	2.4%	26
Aroclor-1254	NA	42	2	4.8%	580
Aroclor-1260	NA	42	2	4.8%	450
delta-BHC	NA	42	1	2.4%	23
PCOC Metals Above Background (mg/kg)[e]					
Calcium	9,340	74	17	23.0%	33521
Chromium	19.98	74	3	4.1%	29
Iron	21,835	74	2	2.7%	51950
Lead	49.6	74	11	14.9%	63
Silicon	2.184	74	0	0.0%	NA
PCOC Radionuclides Above Background (pCi/g)[f]					
Americium-241					
Gross Alpha	0.039	69	69	100.0%	10
Plutonium-239/240	28.771	35	8	22.9%	106
Radium-226	0.094	80	80	100.0%	347
Strontium-89,90	1.198	42	9	21.4%	1
Uranium-233,-234	1.213	30	12	40.0%	2
Uranium-235	1.461	84	28	33.3%	2
Uranium-238	0.107	84	18	21.4%	0
	1.596	84	33	39.3%	3

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TABLE I.5-1 (Continued)

Analyte	Background Screening Level(s)	Number of Samples	Number of Detections[a]	Percent Detections	Mean Concentration or Activity[b]
Semivolatile Organic Compounds (µg/kg)[c]					
Benzo(a)anthracene	NA[d]	42	8	19.0%	87
Benzo(a)pyrene	NA	42	9	21.4%	93
Benzo(b)fluoranthene	NA	42	9	21.4%	134
Benzo(g,h,i)perylene	NA	42	1	2.4%	45
Benzo(k)fluoranthene	NA	42	2	4.8%	73
Benzoic acid	NA	42	39	92.9%	244
Bis(2-Ethylhexyl)phthalate	NA	42	9	21.4%	121
Chrysene	NA	42	12	28.6%	97
Di-n-Butylphthalate	NA	42	1	2.4%	1000
Fluoranthene	NA	42	20	47.6%	153
Indeno(1,2,3-cd)pyrene	NA	42	2	4.8%	64
Phenanthrene	NA	42	13	31.0%	89
Pyrene	NA	42	24	57.1%	131
Water Quality Parameters					
Carbonate (µg/g)	NA	17	4	23.5%	107
pH	NA	11	11	100.0%	7
Specific conductivity (µmhos/cm)	NA	12	12	100.0%	2
Total organic carbon (µg/g)	NA	17	12	70.6%	15850

Locations: SS20093-SS203993, PT006, PT010-011, PT013, PT015-016, PT019-023, PT026-038, PT044-049, PT052-057, PT061-062, PT064-068, PT072-074, PT076-081, PT084-088, PT092-096, PT100-102, PT104-109, PT112-115, PT118-123

[a] Radionuclide and metal results less than the background mean plus 2 standard deviations, the background screening level (BSL), are considered to be non-detection.
[b] The calculation for the mean concentration includes all J, D, and B qualified data.
[c] Background concentrations do not exist and are not applicable for organic compounds.
[d] NA = Not Applicable
[e] For metals and radionuclides, only PCOCs have been reviewed and are presented on this table.
[f] Radionuclide activities less than or equal to zero are considered to be non-detections.

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I.5.2 Summary of Storm Event Surface Water Results

Surface water samples were collected during the overland flow resulting from the May 17, 1995 storm event. The samples were analyzed for Pu-239/240 and Am-241. Figure I.5-2 presents a map of the sampling locations and analytical results. In general, the concentrations of Pu-239/240 and Am-241 are higher in uphill locations (closest to the 903 Pad Drum Storage Site and the 903 Pad Lip Area) than in the downhill locations (closest to South Walnut Creek).

Sampling location Nos. 14 and 16 exceed the surface water derived concentration guidelines (DCG) of 30 pCi/L for Pu-239/240. In addition, sample results from location No. 14 exceed the surface water DCG of 30 pCi/L for Am-241.

The DOE Order 5400.5 *Radiation Protection of the Pubic and the Environment* (DOE, 1990) establishes standards and requirements for operations of the DOE with respect to protection of members of the public and the environment against undue risks from radiation. The DCGs are reference values listed in 5400.5 for conducting radiological environmental protection programs at DOE facilities. The DCGs are based on members of the public ingesting 2 liters/day of water for 365 days/year.

DOE Order 5400.5, states that treatment is not required for surface water discharges which have an annual average concentration below the DCG. Surface water results presented in Figure I.5-2 were collected during a one-time sampling event and, therefore, are not representative of annual radionuclide concentrations at those sampling locations.

I.5.3 Results of Environmental Risk Assessment

The ERA was based on risks posed to the environment by OU2 contaminants as presented in Technical Memorandum No. 9, *Chemicals of Concern, Human Health Risk Assessment, 903 Pad, Mound, and East Trenches, Operable Unit No. 2, 1994,* Draft Final. The ERA methodology is presented in the Technical Memorandum No. 2, *Ecological Risk Assessment Methodology, Site wide Conceptual Model, 1995,* Draft Final. (RMRS, August 22, 1995)

Exposures and risk were estimated for Preble's meadow jumping mouse, the American kestrel, and vegetation. Risk estimates were conducted for PCOCs in surface and subsurface soils. Exposure point calculations for ingestion pathways were evaluated using the 95 percent upper confidence limit (UCL_{95}). Ingestion of chemicals in food and incidental ingestion of soil were evaluated for the mouse and kestrel, exposure to organics in the mouse's burrow air was evaluated, and risks to vegetation were evaluated based on direct contact with subsurface soil (EG&G, May 18, 1995).

Based on the results of the ERA, risks to the Preble's meadow jumping mouse and vegetation are negligible. Risks to the American kestrel were due primarily to chromium and lead in soils and prey. Twenty-one surface soil samples were collected in the vicinity of the 903

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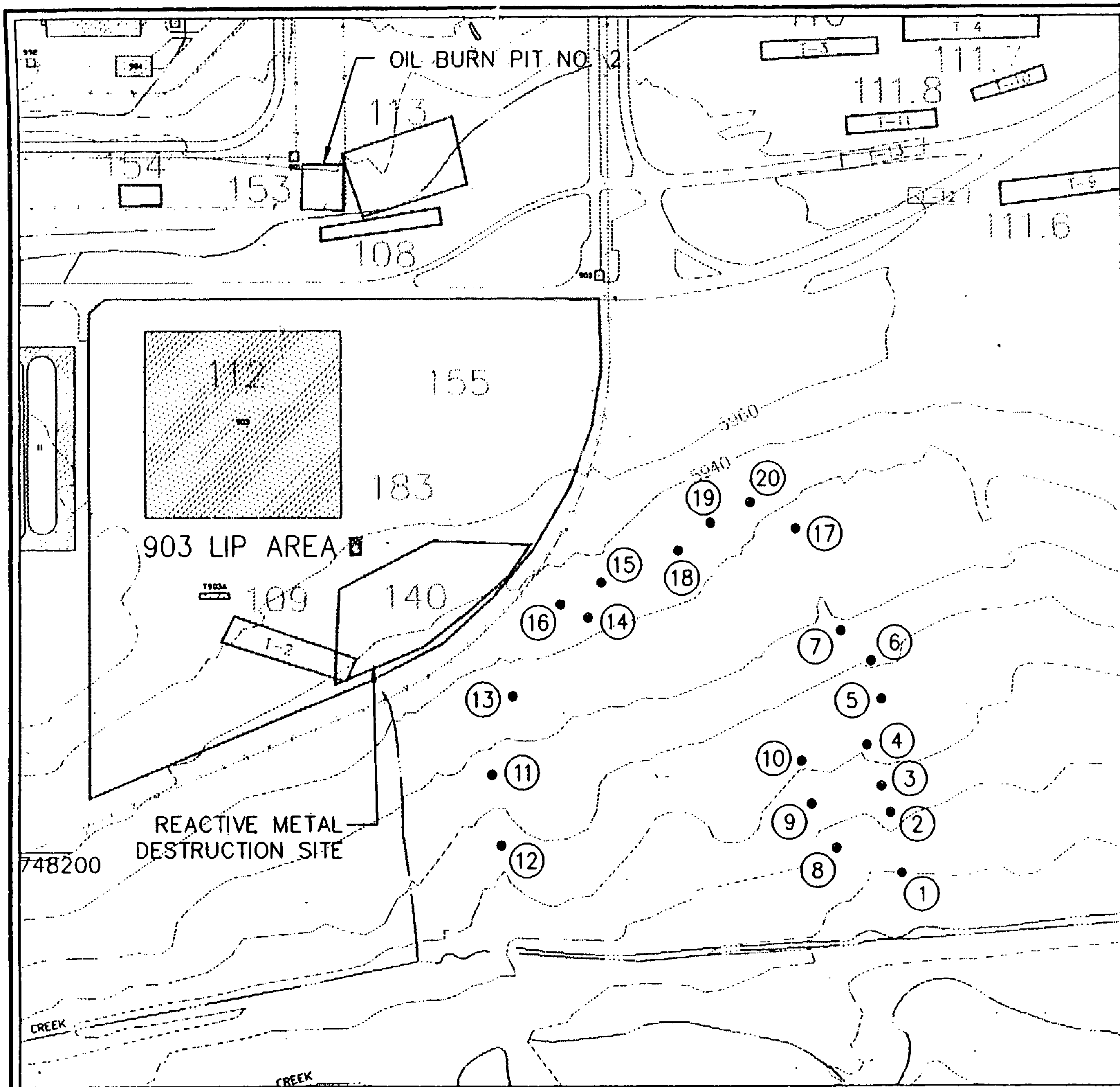

SPRING 1995 RESULTS

SAMPLE LOCATION	Pu-239/240 (pCi/L)	Am-241 (pCi/L)
1	3.81	0.53
2	NA[a/]	0.63
3	NA	1.50
4	NA	0.54
5	8.44	1.36
6	NA	1.14
7	NA	1.05
8	NA	0.70
9	NA	2.11
10	12.19	2.07
11	3.84	0.64
12	2.98	0.45
13	11.16	1.53
14	247.50	48.10
15	NA	26.53
16	38.0	7.68

NA = NOT APPLICABLE

LEGEND

● (1) Sampling Location and Number

0 300 600 FEET

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Figure 1.5-2

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Surface Water Sample Locations

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Pad Drum Storage Site and 903 Pad Lip Area. Of these, only 6 samples (28 percent) exceeded background concentrations. It was reported that only small areas within OU2 have chromium concentrations that could provide an intake to the American kestrel exceeding background. The American kestrel has a large home range over which it forages. Therefore, an American kestrel would likely only take a small fraction of prey from a localized region where chromium concentrations exceeded background. The ERA concluded that it is highly unlikely that the American kestrel population is being impacted by chromium concentrations in OU2 (RMRS, August 22, 1995).

I.5.4 Human Health Risk Assessment Results Summary

An HHRA was conducted as part of the Phase II RFI/RI report for OU2. The purpose of the HHRA was to estimate the level of health risk from potential exposures to chemicals at or released from contaminant sources within OU2. Health risks examined in this document are for the reasonable maximum exposure (RME) case which is an upper bound risk and is calculated according to EPA guidance (EPA, 1989 and EPA, 1992).

The HHRA consisted of a series of four steps involving the collection and evaluation of data as they apply to risk:

- Data collection and evaluation;
- Exposure assessment;
- Toxicity assessment; and
- Risk characterization.

These steps are presented in detail in the RFI/RI report for OU2 (DOE, 1995b). For purposes of this document, only the risk assessment conclusions will be discussed.

I.5.4.1 Results

Table I.5-2 summarizes the results of the risk characterization step of the HHRA for area of concern (AOC) No. 1 , AOC No. 2, and the maximum exposure areas. These are the primary areas assessed within the HHRA. The table highlights the total cancer risk and noncancer hazard indices for the exposure pathways evaluated at OU2. The HHRA supports the no further action remedial alternative since all risk within the AOCs and maximum exposure areas are within the acceptable risk range.

As shown in Table I.5-2 the maximum RME cancer risk estimate was 2.0×10^{-4} for a future industrial/office worker in the 30-acre maximum exposure area. Cancer risk estimates for all other nonresidential receptors and exposure areas were within or below EPA's target cancer risk range of 1.0×10^{-6} to 1.0×10^{-4}. The highest cancer risk estimate of 2.0×10^{-4} only slightly exceeds EPA's target risk range. Noncancer HIs were below one for all onsite nonresidential receptors indicating no significant risk to chemical exposure. Hazard and risk estimates for offsite residents were negligible.

TABLE I.5-2
SUMMARY OF ESTIMATED HEALTH RISKS

	Average Exposure (CT)		Reasonable Maximum Exposure (RME	
	Carcinogenic Risk	Hazard Index	Carcinogenic Risk	Hazard Index
AOC No. 1				
Current worker	$6.0x10^{-7}$	$2.0x10^{-3}$	$1.0x10^{-5}$	$1.0x10^{-2}$
Future industrial/office worker	$2.0x10^{-6}$	$6.0x10^{-3}$	$8.0x10^{-5}$	$4.0x10^{-2}$
Future ecological worker	$1.0x10^{-6}$	$5.0x10^{-3}$	$4.0x10^{-6}$	$2.0x10^{-2}$
Future open space use	$2.0x10^{-7}$	$5.0x10^{-4}$	$1.0x10^{-5}$	$1.0x10^{-2}$
Future construction worker	$1.0x10^{-7}$	$4.0x10^{-3}$	$3.0x10^{-7}$	$2.0x10^{-8}$
Maximum Exposure Areas				
Future industrial/office worker (30 acres)	$5.0x10^{-6}$	$1.0x10^{-2}$	$2.0x10^{-4}$	$8.0x10^{-2}$
Future ecological worker (50 acres)	$2.0x10^{-6}$	$8.0x10^{-3}$	$6.0x10^{-6}$	$4.0x10^{-2}$
AOC No. 2				
Current worker	$9.0x10^{-9}$	$3.0x10^{-7}$	$2.0x10^{-7}$	$2.0x10^{-6}$
Future industrial/office worker	$4.0x10^{-8}$	$9.0x10^{-7}$	$1.0x10^{-6}$	$1.0x10^{-5}$
Future ecological worker	$2.0x10^{-8}$	$2.0x10^{-4}$	$7.0x10^{-8}$	$3.0x10^{-4}$
Future open space use	$6.0x10^{-9}$	$3.0x10^{-5}$	$3.0x10^{-7}$	$4.0x10^{-4}$
Future construction worker	$3.0x10^{-8}$	$3.0x10^{-3}$	$1.0x10^{-7}$	$2.0x10^{-2}$

Estimated annual radiation doses for nonresidential onsite receptors were less than 20 millirem (mrem) per year, well below the DOE standard of 100 mrem per year for protection of the public.

The hypothetical resident was not included in the risk characterization since this exposure scenario is not applicable at the RFETS. The hypothetical resident is not an applicable exposure scenario given recent regulatory rulings which prohibit the future development of the land for residential use. Therefore, the residential risk calculations were not considered in making conclusions about site risk.

The EPA's *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (EPA, 1991a), states that for sites where the cumulative risk to an individual based on RME for both current and future land use is less than 1.0×10^{-4}, action is generally not warranted, but may be warranted if a chemical-specific standard that defines acceptable risk is violated. In addition, a risk manager may also decide that a lower level of risk to human health is unacceptable and that remedial action is warranted. Chemical-specific standards have been calculated for OU2 and are further discussed as remediation goals in the following subsection.

I.5.5 Remediation Goals

As discussed in the *Risk Assessment Guidance Document, Part B* (EPA, 1991b), remediation goals are long-term targets to use during analysis and selection of remedial alternatives. Ideally, such goals, if achieved, should both comply with ARARs and result in residual risks that fully satisfy the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requirements for protection of human health and the environment.

Chemical-specific remediation goals are concentration goals for individual chemicals for specific medium and land use combinations at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites. There are two general sources of chemical-specific remediation goals: 1) concentrations based on ARARs and TBC standards, and 2) risk-based calculations that set concentration limits using carcinogenic and/or noncarcinogenic toxicity values under specific exposure conditions. The remediation goals for contaminants of concern for surface soil were originally identified in Technical Memorandum No. 1 (DOE, 1995a) and modified based on the HHRA.

Table I.5-3 presents the remediation goals used to screen and calculate contaminated surface soil volumes and evaluate remedial alternatives for the 903 Pad and Windblown Soils IM/IRA. The maximum contaminant concentration is presented for comparison against the remediation goals to determine which contaminants warrant further evaluation in the 903 Pad and Windblown Soils IM/IRA decision document. Appendix B contains the calculations for the remediation goals presented in Table I.5-3 and estimated surface soil volumes based on an office worker scenario inside the industrial area of RFETS, and an open space exposure scenario outside of the industrial area.

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TABLE I.5-3
REMEDIATION GOALS

Contaminant of Concern	Maximum Detected Concentration[b]		Regulatory Based Remediation Goal[c]	Risk-Based/Dose Remediation Goals[a]			
				Office Worker		Open Space	
	Inside 903 Pad Lip Area	Outside 903 Pad Lip Area		Risk-Based	15 mrem	Risk-Based	15 mrem
Aroclor-1254 (mg/kg)	9.70×10^{-1}	2.20×10^{-1}	2.5×10^{1}	NA[d]	NA	NA	NA
Aroclor-1260 (mg/kg)	6.60×10^{-1}	2.20×10^{-1}	2.5×10^{1}	NA	NA	NA	NA
Bis (2-ethylhexyl)phthalate (mg/kg)	5.10×10^{-1}	4.5×10^{-1}	---	4.09×10^{2}	NA	1.28×10^{3}	NA
Chromium III(mg/kg)	3.21×10^{1}	2.95×10^{1}	---	2.04×10^{6}	NA	2.19×10^{6}	NA
Plutonium-239/-240 (pCi/g)	1.10×10^{4}	7.3×10^{3}	---	---	1.64×10^{3}	---	1.61×10^{4}
Americium-241 (pCi/g)	2.70×10^{2}	1.64×10^{2}	---	---	1.42×10^{2}	---	1.43×10^{3}

a/ Remediation goals based on reasonable maximum exposure factors.
b/ Maximum concentration originates from RFI/RI for OU2.
c/ TSCA (See 40 CFR 761.120 and 761.125)
d/ NA = Not applicable because remediation goal is either regulatory-based, risk-based, or dose-based value and therefore is not included.

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I.5.5.1 Chemical-Specific ARARs/TBCs

Chemical-specific ARARs/TBCs for surface soil, which establish protective levels based on protection to human health and/or the environment, exist for PCBs and radionuclides. Cleanup standards for soils contaminated with PCBs are regulated under the Toxic Substances Control Act (TSCA). The TSCA requirements for cleaning up PCB spills are considered TBC criteria. Although PCB spills that occurred prior to May 4, 1987 are excluded from 40 CFR 761, Subpart G (EPA's PCB Spill Cleanup Policy), DOE believes that the cleanup targets in the policy are protective of human health and the environment. The Policy establishes a soil cleanup target of 25 parts per million (ppm) PCBs by weight in restricted areas. The DOE believes that the 903 Pad and associated windblown soils meet the definition of a restricted area, as they are located within an industrial site where access is limited and separated by over 0.1 kilometers from any residential/commercial area as defined in 40 CFR Section 761.123. There were no surface soil concentrations that exceeded the 25 ppm remediation goal. Therefore, no surface soils in the 903 Pad and Windblown Soils Area require remediation for PCB contamination.

The TBC criteria identified for plutonium and americium in Technical Memorandum No. 1 (DOE, 1995a) were based on an annual radiation dose limit of 100 mrem effective dose equivalent using the office worker exposure scenario and exposure pathways outlined in the *Programmatic Risk-Based Preliminary Remediation Goals* (DOE, 1994) and the RME parameters agreed to by the EPA, CDPHE, and the DOE. The equation was modified to use dose (mrem) instead of a target risk level in the numerator, and a dose equivalent factor (mrem/μCurie) instead of a cancer slope factor in the denominator. The DOE Order 5400.5, (DOE, 1990) restricts the offsite radiation dose to members of the public to a 100 mrem effective dose equivalent per year. Following completion of the HHRA, the TBC criteria was modified to reflect site-specific conditions and exposure parameters used in the HHRA. These modifications included revising the exposure scenario using an office worker exposure scenario inside the industrial area of RFETS, and an open space exposure scenario outside the industrial area.

The 100 mrem effective dose equivalent presented in DOE Order 5400.5 was intended to apply to doses to the public resulting from all exposure modes from all DOE routine activities. To limit the dose resulting from a single source and ensure the standard was protective of human health and the environment, the TBC criterion was further revised to reflect an annual radiation dose limit of 15 mrem effective dose equivalent. In addition, the 15 mrem remediation goal is consistent with the proposed Nuclear Regulatory Commission (NRC) radiological criteria for decommissioning (59 FR 43200, August, 1994).

I.5.5.2 Risk-Based Remediation Goals

Because no ARAR/TBC criteria were identified for surface soil containing bis(2-ethylhexyl)phthalate and chromium III, risk-based remediation goals were calculated in Technical Memorandum No. 1 (DOE, 1995a). These remediation goals were modified to reflect site-specific conditions and exposure parameters used in the HHRA.

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I.5.5.3 Summary of Results

A comparison of the maximum contaminant values against the remediation goals indicate that both Pu-239/240 and Am-240 exceed the remediation goals based on a 15 mrem effective dose equivalent and warrant further consideration in the 903 Pad and Windblown Soils Area IM/IRA decision document.

I.6 ESTIMATION OF AREAS REQUIRING REMEDIATION BASED ON AN ANNUAL DOSE OF RADIOACTIVITY

Surface soil contamination levels, based on RFI/RI data, were compared against radiation dose-based remediation goals to establish the areal extent of contaminated soils requiring remediation. Figure I.6-1 identifies those areas within the 903 Pad and Windblown Soils Area that exceed the remediation goals. Surface soils outside IHSS 155, including the East Spray Fields (IHSSs 261.2 and 261.3) do not require remediation to achieve a 15 mrem effective dose equivalent based on the open space exposure scenario. Similarly, surface soils in IHSS 183, the Gas Detoxification Site, do not require remediation to achieve the remediation goals.

Within IHSS 155, approximately 3.1 acres outside of the 903 Pad Drum Storage Site require remediation to achieve the remediation goals based upon the office worker exposure scenario (see Appendix B). The results of the RFI/RI indicate that outside the 903 Pad Drum Storage Site, over 95 percent of the Pu-239/240 and Am-241 contamination is confined to the upper 20 cm of soils, and soils at the surface exhibit the highest contamination levels. Therefore, a 20 cm depth was assumed as the extent to which soils will be remediated. At this depth, a total volume of 3,280 cubic yards of contaminated surface soils require remediation for the 3.1 acres exceeding the remediation goal.

The 903 Pad Drum Storage Site will be remediated to prevent potential future surface erosion and transport of contaminated soils that are currently beneath the pad. The volume of contaminated soil beneath the 903 Pad, as well as the volume of the asphalt pad itself, were examined. During past remedial actions at the 903 Pad Drum Storage Site, approximately 20 cm of clean fill and a layer of asphalt were placed over contaminated soils. Although the 20 cm of fill may not be thoroughly contaminated, the entire volume is suspect and will require screening during an excavation scenario. The 20 cm of soil under the fill contains the majority of the contamination beneath the 903 Pad. The total volume of contaminated material to be remediated from under the 903 Pad is estimated at 8,570 cubic yards. The total estimated volume of contaminated surface soil requiring remediation is 11,850 cubic yards. This volume estimate was rounded up to 12,000 cubic yards for use in the evaluation of remediation process options and alternatives.

I.7 IM/IRA ASSUMPTIONS

The following assumptions have been made in preparing this IM/IRA:

Figure I.6-1 Areas Which Exceed Remediation Goals

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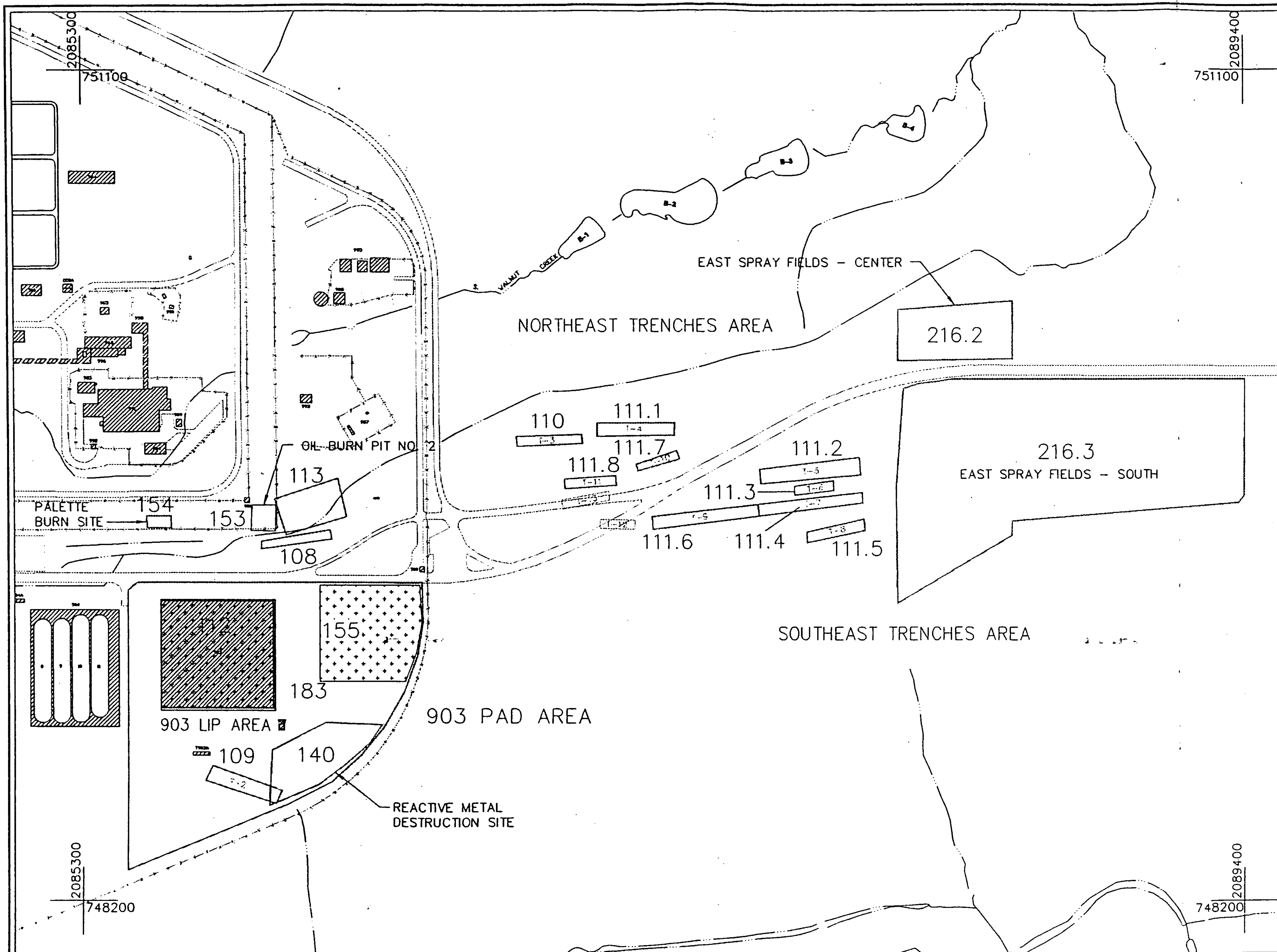

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Figure L 6-1

Operable Unit No. 2
Interim Measure/ Interim Remedial Action
Areas Which Exceed Remediation Goals

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- All wastes associated with the surface soil remediation are nonhazardous, low-level radioactive wastes.

- The remediation goals as outlined in this document for the office worker and open space exposure scenarios are approved for use.

- Concentrations of Am-241 and Pu-239/240 in the soil under the 903 Pad Drum Storage Site exceed the office worker remediation goals and require remediation.

- Post surveys will be performed on all areas requiring remediation to assure that remediation goals have been met. Post survey results show that the remediation goals for Pu-239 and Am-241 are not exceeded.

- Concentrations of the COCs in IHSSs 216.2 and 216.3, the north and center portions of the East Spray Field, do not exceed the remediation goals and, therefore, do not require further remediation.

- IHSS 183, the Gas Detoxification Building, may be removed during the remediation activities of the 903 Pad Lip Area and the 903 Pad Drum Storage Site.

- Remediation of groundwater and subsurface soils is not within the scope of this surface soil IM/IRA project.

- Am-241 and Pu-239/240 in the surficial soils outside of the 903 Pad Drum Storage Site but within the industrial area fence exceed the office worker remediation goals and require remediation. A surficial soil survey will be performed before remediation proceeds to assure that the remediation goals are exceeded.

- Am-241 and Pu-239/240 in the surficial soils outside of the industrial area fence do not exceed the open space remediation goals and do not require remediation.

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II.1 GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS

This section presents the general response actions (GRAs), remedial technologies, and potential process options that were identified and initially screened as part of the surface soils evaluation presented in Technical Memorandum 2 for OU2 (DOE, 1995c). GRAs were identified to satisfy the remedial action objectives established for OU2. These GRAs represent a full range of potential actions to ensure that a reasonable range of remedial alternatives have been evaluated. A general description of each GRA is provided below.

- No Further Action - Required by CERCLA as a benchmark for comparison against other remedial action alternatives. No direct action will be taken to alter the existing situation. Long-term air, surface water, and radiological monitoring of site conditions would be performed.

- Institutional Controls - Refers to controls based on legal and/or management policies which minimize public exposure to potential contaminants. The land use would be legally restricted by zoning provisions and/or modification to the deed, and site access would be limited with fencing. Long-term air, surface water, and radiological monitoring would be conducted.

- Containment - Consists of those actions which would minimize or prevent migration of contaminants by wind dispersion or surface water erosion mechanisms.

- *In Situ* Treatment - *In situ* treatment refers to treatment of contaminants in place. *In situ* treatment actions would remove, detoxify, and/or immobilize contaminants using chemical, thermal, physical, or biological technologies.

- Excavation and Disposal - Includes actions such as soil excavation which are used to remove and/or consolidate contaminated media. Also includes transportation and disposal of radioactive wastes at facilities such as a landfills and vaults.

- *Ex Situ* Treatment - This action is similar to *in situ* actions with the exception that the contaminated media are extracted or removed prior to treatment. *Ex situ* actions separate or concentrate, detoxify, or immobilize contaminants using chemical, thermal, physical, or biological technologies.

II.1.1 Identification of Technologies and Process Options

Remediation technologies and process options were identified to address contaminated surface soil at the 903 Pad and Windblown Soils Area. A comprehensive list of remediation technologies and process options was developed for the RFETS as part of Task 3 of the CMS/FS (EG&G, 1994). Resources consulted to compile the comprehensive list of technologies (ES, 1994) included:

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(EG&G, 1994). Resources consulted to compile the comprehensive list of technologies (ES, 1994) included:

- EPA and DOE guidance documents;
- Technical publications, journals, and proceedings;
- Computerized remediation and waste treatment databases, including EPA's Vendor Information System for Innovative Treatment Technologies (VISITT), Risk Reduction Environmental Laboratory (RREL) Treatability Database, and Alternative Treatment Technology Information Center (ATTIC); and
- Existing RFETS documents, including treatability studies and IM/IRA reports.

Information provided in the comprehensive list of technologies and additional EPA and DOE guidance documents was used to perform an initial screening of technologies and process options based on OU2-specific conditions.

II.1.2 Screening of Technologies and Process Options

The list of technologies and process options was screened against established criteria for applicability and implementability. The goal of the initial screening process was to eliminate those technologies and/or process options that could not be implemented because of site-specific factors. This step reduced the number of remedial technologies and process options for consideration in the development of remedial alternatives.

Process options were initially screened and evaluated under the assumption that they would be implemented as the primary remedial treatment process. Therefore, several process options were not retained after screening because they were only applicable as a secondary treatment or a component of a potential remedial alternative.

The second screening was a fatal-flaw analysis based solely on technical implementability. This stage of screening required the review of site characteristics and specific information for each process option to identify any factor that would prevent the technology or process option from being implemented at the 903 Pad and Windblown Soils Area for surface soil remediation. Factors affecting technical implementability that were considered during the fatal-flaw analysis included:

- Characteristic contaminant properties;
- COC concentrations;
- Horizontal and vertical extent of contamination; and
- Surface topography.

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If any factor or combination of factors that would prevent a process option from being implemented was identified, that process option was eliminated from further consideration and the reason was documented. The process options remaining after the initial screen were evaluated based on potential effectiveness, administrative implementability, and relative cost. Specific factors considered within each of these categories include the following.

Effectiveness:

- Potential effectiveness of process options in handling anticipated areas or volumes of contaminated media;

- Potential effectiveness of process options in meeting the C/RAOs;

- Potential impacts to human health and the environment of process options during construction and implementation; and

- Proven applicability and reliability of process options given current understanding of the site-specific conditions and contaminant concentrations.

Implementability:

- Availability of required treatment, storage, and disposal (TSD) services for process options;

- Ability to obtain necessary approvals and permits for process options;

- Availability of required equipment and skilled workers for implementation of process options; and

- Constructability of process options, including site-specific constraints such as, access, topography, time, and regulatory commitments.

Relative Cost:

- The cost estimates were developed using several sources. Horizontal barrier process options primarily used RFETS site-specific data developed for cover alternatives at OU4. The disposal and treatment process options primarily were referenced from the RFETS Environmental Restoration Management Cost Estimating Manual, Document No. RFP/ERM-94-00009 (Parsons ES & Rust, 1994). Where additional information was required, the EPA Remediation Technologies Screening Matrix and Reference Guide, Document No. EPA 542-B-93-005 (EPA, 1993) was used. Estimates for disposal and transportation also used the detailed estimates developed for OU4.

- The accuracy of the cost estimates at this screening step was plus or minus 100 percent. Estimates are intended to be used only for comparisons of one process option to another within a technology type.

The results of the screening process are presented in Figure II.1-1. Based on the screening process, the most appropriate process options were carried forward and developed into specific remedial alternatives for the 903 Pad and Windblown Soils Area. The remedial alternatives carried forward into the detailed analysis of alternatives included:

- No further action;
- Institutional controls;
- Enhanced vegetative cover;
- Excavation and onsite disposal; and
- *Ex Situ* treatment via stabilization with return to excavation.

The following section provides an engineering description of these alternatives.

II.2 DETAILED DESCRIPTIONS OF REMEDIAL ALTERNATIVES

For each of the remedial alternatives, the selected primary process components are listed and described regarding size and configuration of equipment needed, process rates and remedial durations expected, constructability issues, and permitting. Estimated times for completion do not include pre-remediation management or mobilization/demobilization. The information presented in the following subsections will provide the technical basis for the detailed analysis of alternatives (DAA).

II.2.1 Alternative 1: No Further Action

The no furth·· action alternative would involve no additional remedial activities or institutional controls. No process options require development or evaluation for this alternative. The no further action alternative is required as a basis for comparison with the other remedial alternatives.

Remedial activities associated with this alternative include monitoring for radioactive airborne particulates, ambient gamma field monitoring, and monitoring of radioactivity in surface water. Radiological monitoring would be conducted to evaluate potential contaminant migration from the site via air dispersion pathways, upward migration to the surface via biota transport, and surface water runoff.

Monitoring for radioactive particulates and surface soil hot spots would include both radioactive airborne particulate and ambient gamma field monitoring. The RFETS currently conducts both types of monitoring on a regular basis. Long-term monitoring would continue until it is determined that the radiation dose from the surface soil is at acceptable levels.

Surface Soil General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[b]
No Further Action	None	Not Applicable	Does not achieve C/RAOs.	Difficult regulatory/community acceptance.	None
Institutional Controls	Access Restrictions	Fencing, Security, etc.	May achieve C/RAOs. Effectiveness depends on continued future implementation. Does not reduce contamination.	Difficult regulatory/community acceptance.	Low capital, low O&M.
	Land Use Restrictions	Deed Restrictions	May achieve C/RAOs. Effectiveness depends on continued future implementation. Does not reduce contamination.	Difficult regulatory/community acceptance.	Low capital, low O&M.
		Zoning Restriction	May achieve C/RAOs. Effectiveness depends on continued future implementation. Does not reduce contamination.	Difficult regulatory/community acceptance.	Low capital, low O&M.
	Monitoring	Fugitive Dust Monitoring	Effective monitoring method.	Easily implemented.	Low capital, low O&M.
Containment	Horizontal Barriers	Vegetative Cover	May achieve C/RAOs with restrictions on future land use.	Easily implemented.	Low capital, med O&M.
		Asphalt-Based Cover	May achieve C/RAOs with restrictions on future land use. Eliminated due to long-term effectiveness and high maintenance requirements.	Easily implemented.	Low capital, med O&M.
		Compacted-Clay Cover	May achieve C/RAOs with restrictions on future land use. Eliminated because it may crack in semi-arid environment.	Difficult implementation.	High capital, med O&M.
		Multi-Layer Cover	May achieve C/RAOs with restrictions on future land use.	Easily implemented. Long implementation schedule.	High capital, med O&M. Eliminated because cost prohibitive.
In situ Treatment	Solidification/ Stabilization	Stabilization, Slurry Injection, Solidification, Cementation, Encapsulation	Effectiveness and reliability evaluations require treatability study. Eliminated long-term effectiveness suspect and quality assurance of solidified product is difficult.	Average implementability	Insufficient data

LEGEND

xxxx Technology or process option eliminated from further evaluation.

Notes: [b] Cost evaluation is relative only within remedial technology groupings.

(Continued next page)

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Figure II.1-1 (Sheet 1 of 3)

Operable Unit No. 2
Interim Measure/Interim Remedial Action
Results of Screening Process

Surface Soil General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
Removal	Excavation	Soil Excavation	Appears to meet C/RAOs. Would require controls to prevent mobilization of contaminants.	Easily implemented.	Low capital, low O&M.
	Short Distance Transport	Conveyor System	Effective, reduces mobility of contaminants. Would require controls to prevent mobilization of contaminants.	Easily implemented.	High capital, med O&M.
		Slurry Pipeline	Effective, reduces mobility of contaminants. Would require controls to prevent mobilization of contaminants.	Easily implemented.	High capital, high O&M.
	Long Distance Transport	Truck/Rail Hauling	Effective, reduces mobility of contaminants. Would require controls to prevent mobilization of contaminants.	Easily implemented. DOT permits may be required.	High capital, low O&M.
	Offsite Storage/Disposal	Landfill/TSD Facility	Effective, reduces mobility of contaminants. Would require controls to prevent mobilization of contaminants.	Easily implemented. Risk to public exists during transportation.	High capital, low O&M. Eliminated because cost prohibitive.
	Onsite Storage/Disposal	Disposal Vault	Effective, reduces mobility of contaminants. Would require controls to prevent mobilization of contaminants.	Difficult implementation, would require permits, and construction of onsite TSD facility.	High capital, low O&M. Eliminated because cost prohibitive.
		Container Storage	Effective, reduces mobility of contaminants. Would require controls to prevent mobilization of contaminants. Eliminated because not long-term solution.	Difficult implementation, RFETS has permitted storage areas; however, capacity may be limited. Long-term storage may not be acceptable.	Low capital, med O&M.
		Permitted Landfill	Effective, reduces mobility of contaminants. Would require controls to prevent mobilization of contaminants.	Difficult implementation, would require permits and construction of onsite TSD facility.	High capital, med O&M.

LEGEND

Technology or process option eliminated from further evaluation

(Continued next page)

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Figure II.1-1 (Sheet 2 of 3)

Operable Unit No. 2
Interim Measure/Interim Remedial Action
Results of Screening Process

Surface Soil General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[a]
Ex situ Treatment	Chemical/Physical	Chemical Red/Ox (1)	Effectiveness and reliability evaluations require treatability study. Eliminated because not considered a stand alone process option, and must be used in a treatment train.	Insufficient data available to rate this process option.	Insufficient data.
		Soil Washing (2)	Effectiveness and reliability evaluations require treatability study. Current treatability work looks promising. Generates secondary wastes. Eliminated because not considered a stand alone process option, and must be used in a treatment train.	Average implementation.	Med capital, med O&M.
		Electrokinetics	Effectiveness and reliability evaluations require treatability study. Eliminated because not considered a stand alone process option, and must be used in a treatment train.	Difficult implementation, innovative technology.	High capital, med O&M.
	Biological	Biological Leaching (3)	Effectiveness and reliability evaluations require treatability study. Work at RFETS in early stages.	Eliminated because insufficient data to determine if this process option is implementable.	Insufficient data.
	Solidification/Stabilization	Stabilization (4)	Effectiveness and reliability evaluations require treatability study. Effectiveness for heavy metals is established.	Average implementability, TSD services for heavy metals may be applicable.	Insufficient data.
		Encapsulation	Effective, appears to meet C/RAOs. Would require controls to prevent mobilization of contaminants. Eliminated because it is a subset of stabilization	Average implementability.	Medium capital, med O&M.
		Cementation	Average effectiveness, appears to meet C/RAOs. Would require controls to prevent mobilization of contaminants. Subset of stabilization. Eliminated because it is a subset of stabilization.	Easily implemented.	Low capital, med O&M.
		Vitrification: (Plasma Arc, Slagging Furnace, Joule-Heated, Glass Melter)	Effective, appears to meet C/RAOs. Would require controls to prevent mobilization of contaminants. Requires treatability test.	Eliminated because of difficult implemention from excessive energy and highly trained personnel requirements.	High capital, med-high O&M.

NOTE: Process options are components of the following treatment systems or studies:

(1) Aqueous Biphase Separation (ABS)
(2) TRU Clean®
Gravity/Flotation/Chemical Enhancement (NRT Study)
Chemically Enhanced Steam Stripping (CESS)
Chelating Aquants (LANL Study)
(3) MBX Study (Lockheed)
(4) WES-PHIX Process

LEGEND

xxx Technology or process option eliminated from further evaluation.

Notes: [a] Cost evaluation is relative only within remedial technology groupings.

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Figure II.1-1 (Sheet 3 of 3)

Operable Unit No. 2
Interim Measure/Interim Remedial Action
Results of Screening Process

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Monitoring for radiation present in surface water would be required to determine if contaminants were migrating via surface water runoff and having an adverse impact on South Walnut Creek or Woman Creek. The RFETS currently collects surface water samples as part of the site-wide environmental protection program. The surface water runoff monitoring could be implemented as part of the site-wide program with minimal effort.

II.2.2 Alternative 2: Institutional Controls

Institutional controls reduce potential exposures to site contaminants through administrative actions and access restrictions. Administrative actions include deed restrictions to control future land use, and long-term monitoring to determine whether contaminants are migrating. Deed restrictions impose legally enforceable controls to prevent development, excavation, or construction on the land to prevent contact with and mobilization of contamination. Access restrictions include fencing and warning signs. Specific institutional controls are described below.

II.2.2.1 Access Restrictions

A 6-foot-high fence with warning signs would be installed around the area with surface soil concentrations of Pu-239/240 and Am-241 above the remediation goals. Approximately 4,250 linear feet would be required around the 903 Pad Lip Area. It is expected that the fencing would be installed within several months from approval of the IM/IRA decision document.

II.2.2.2 Deed Restrictions

Deed restrictions would be imposed to ensure that excavation, construction, or other high risk activities did not occur within controlled areas. By imposing deed restrictions on the site, contact with contaminated soils and spreading of contaminated surface soils due to disturbance would be significantly reduced. The deed restrictions would remain in place until it was determined that unrestricted use of OU2 surface soils was deemed acceptable. A permanent notation would be made in the legal land record of the local governmental agency stating that Pu-239/240 and Am-241 contamination is present at the site.

II.2.2.3 Radiological Monitoring

Monitoring would be performed to ensure that radioactive airborne particulates, ambient gamma field levels, and surface water runoff from the site are not above determined action levels. Monitoring would be conducted as part of the RFETS site-wide monitoring and would continue for at least 30 years. The monitoring activities would be reviewed every 5 years in accordance with CERCLA.

II.2.3 Alternative 3: Enhanced Vegetative Cover

This alternative would cover the contaminated soils in place in the 903 Pad Drum Storage Area. The contaminated soils from the 903 Pad Lip Area would be consolidated beneath the cover in the 903 Pad Drum Storage Area. The site would be cleared of debris and vegetation, then graded prior to the placement of the enhanced vegetated cover. A conceptual diagram of this remedial alternative is presented in Figure II.2-1.

From the bottom to the top, the cover would consist of a riprap layer placed directly on the final grade, a gravel layer, a geotextile fabric, a layer of clean imported backfill, and a layer of topsoil. The topsoil would be seeded with native vegetation. Figure II.2-2 presents a possible cross-section of the enhanced vegetative cover.

Water and wind erosion would be controlled by the vegetation. The vegetation would interrupt water flow paths, reduce flow velocities, and provide surface irregularities for sediment deposition. The vegetation would also enhance soil stability. The entire cover system would reduce the potential for direct contact with the contaminated soils that currently are at the surface.

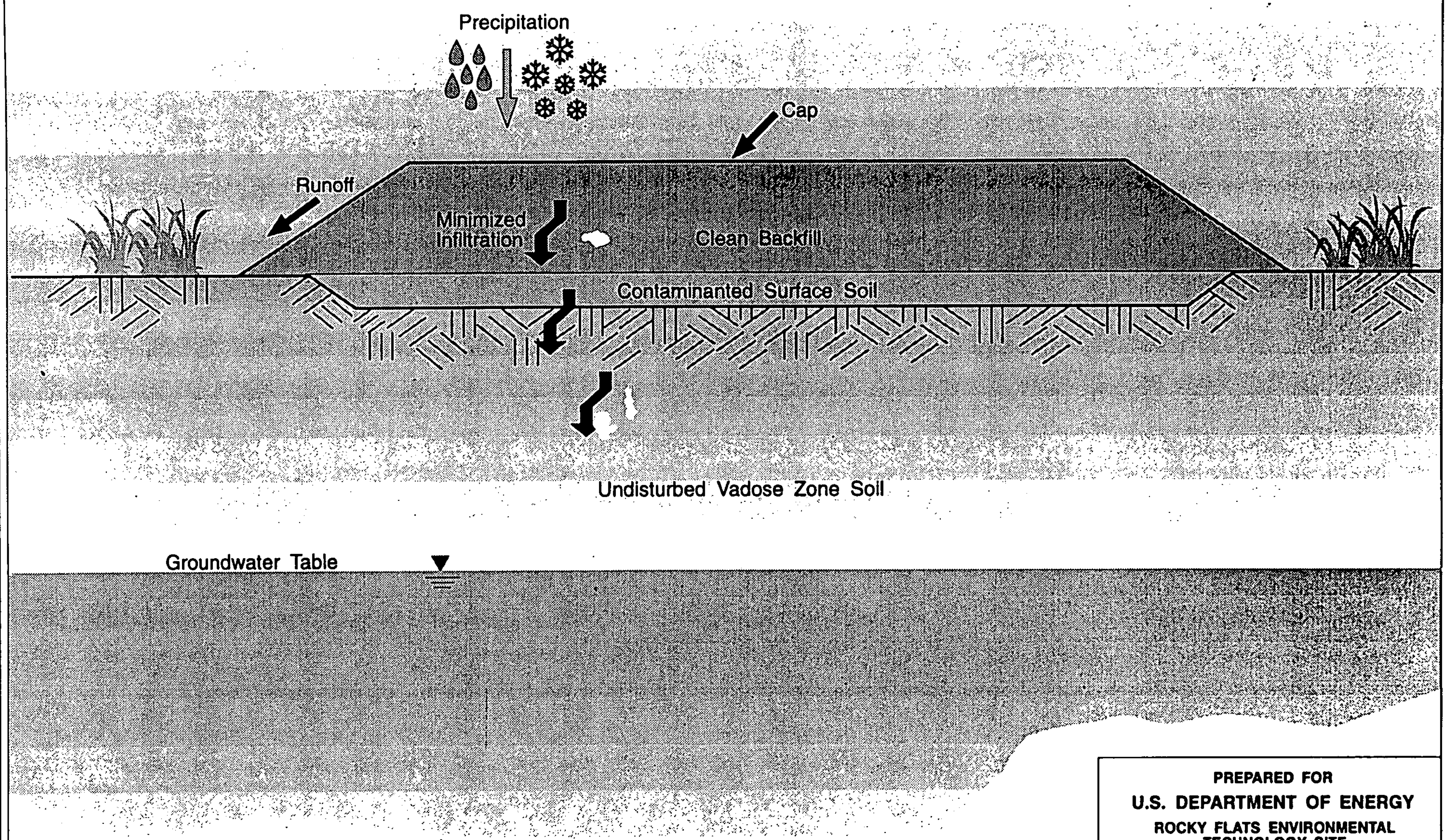
It is believed that macropore flow, lateral discontinuity, and biological activities (i.e., burrowing and/or soil mixing by earthworms, rodents, and ants) have contributed to the mobilization of contaminants in shallow soils at the 903 Pad and Windblown Soils Area. The incorporation of the riprap and gravel layers and the geotextile fabric is expected to control biological vectors and reduce precipitation infiltration.

Construction activities to implement an enhanced vegetative cover would include clearing, filling, and grading; material placement; and revegetation of the cover area as well as surrounding areas affected by the construction operations. This alternative could be implemented within a 4-month period. The following subsections describe the Alternative 3 components.

II.2.3.1 Site Preparation and Grading

Site preparation would include clearing operations to remove oversized debris, rocks, and any other obstacles that would interfere with the placement of the cover materials and the final design grade. Approximately 3,200 cubic yards of hillside soils would be removed, placed and graded over the asphalt pad. Standard earthmoving equipment such as bulldozers, scrapers, loaders, and dump trucks would be used for these activities. A water truck would be used to control dust. Clearing and grading operations for the 3.1-acre site would require approximately 5 days.

Compaction beyond that provided by normal operation of the earthmoving equipment should not be required. The cover would have a slight grade to provide positive drainage without causing soil erosion. To the maximum extent practical, the final grade would match the existing ground surface. Grading operations would use standard earthmoving equipment such



Note:
Contaminated surface soil is capped in place.

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Figure II.2-1

Operable Unit No. 2
Interim Measure/Interim Remedial Action
Alternative 3
Enhanced Vegetative Cover

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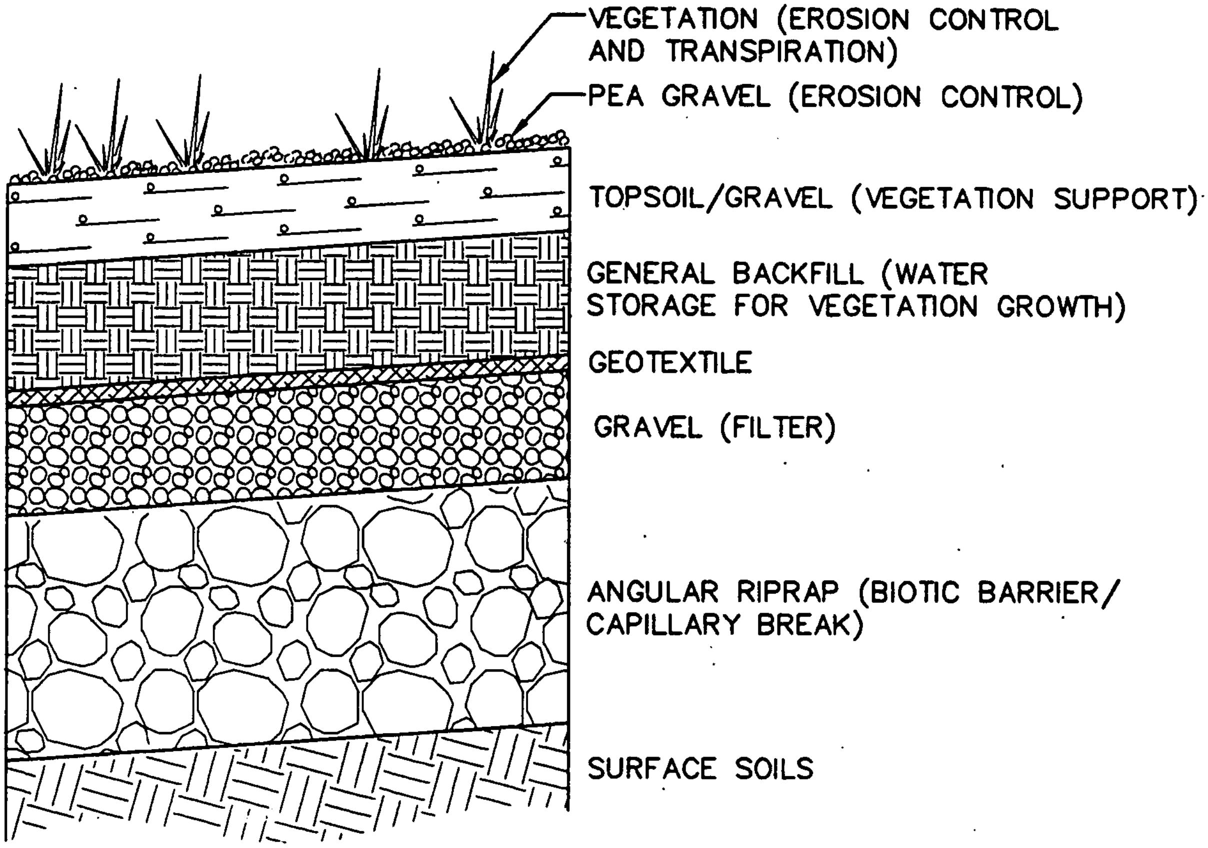

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NOTE:

1. THIS SKETCH REPRESENTS PRELIMINARY DESIGN CONCEPTS. IF SELECTED, THE FINAL CONFIGURATION WILL BE DEVELOPED ON DESIGN DRAWINGS.

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Figure II. 2-2

Operable Unit No. 2
Interim Measure/ Interim Remedial Action
Enhanced Vegetative Cover Cross Section

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as bulldozers, loaders, and, if clean fill is imported, dump trucks. The estimated time required to remove and transport contamianted surface soils from the 3.1-acre area to the 903 Pad is approximatley 5 days.

II.2.3.2 Installation of Enhanced Vegetative Cover

Construction of the enhanced vegetative cover would begin with placement of the riprap and gravel layers. These layers would be sized to create a capillary break as well as a biotic barrier. These layers would then be covered with a geotextile fabric, and topped with 18 inches of clean imported fill and 12 inches of topsoil material.

The underlying riprap and gravel layers will serve multiple functions. First, they will provide a biotic barrier against root growth and animal migration. Root penetration will stop when the roots encounter repeated air voids in the gravel layer. The burrowing mammal species most common to the RFETS area are prairie dogs and badgers. Neither of these species will burrow through riprap or gravel. Therefore, the layers of riprap and gravel will deter the animals from burrowing down into the contaminated surface soils.

The riprap and gravel layers also will provide a significant increase in pore size in comparison to the relatively fine-grained soils above them, thereby encouraging a capillary break. The capillary break will cause moisture to be retained in the upper fine-grained soils, which have a higher surface tension and a negative pressure within the pores of the fine-grained soil matrix. Significant amounts of moisture will only percolate down into the relatively large voids of the riprap and gravel layers when the overlying fine-grained soils become saturated. While the subgrade underlying the riprap and gravel layers would not be a completely impermeable layer, it would be a tightly compacted surface. This would encourage lateral drainage within the riprap and gravel layers and reduce the amount of moisture infiltration into the contaminated soils. It is also anticipated that the riprap and gravel layers will hinder the upward movement of worms through the contaminated soils and into the topsoil portion of the enhanced vegetative cover.

Geotextile fabric would serve dual functions in the cover. First it would provide the filtering necessary to segregate the overlying fine-grained soils that support vegetation from the underlying gravel layer. This filtering action will maintain the void spaces between the two earthen materials, creating the capillary break. The geotextile material will have an appropriate mesh size to maintain the required filtering between the clean backfill and gravel layers. Second, the geotextile will serve as a biotic barrier for plant root growth and earthworms.

Vegetation will play a critical role in the enhanced vegetative cover. Its soil binding properties and the physical cover it provides will be the major protection against wind and water erosion of the cover. In addition, vegetation removes moisture through the transpiration process. This, coupled with the natural evaporation process, forms a moisture removal process called evapotranspiration (ET). The estimated ET rate in the RFETS region exceeds the average annual precipitation by as much as three times. Therefore, an enhanced vegetative cover is expected to remove the majority of the precipitation percolation before infiltration would occur.

The vegetation species would be chosen to blend with the surrounding species as well as their ability to withstand drought and erosive forces. The species chosen would include cool season grasses which will come out of dormancy early in the spring, thereby allowing the ET process to begin early in the season. Some early-to-establish species would also be included to allow for early protection of the topsoil from wind and water erosion. Seeding operations would be performed with either a hydroseeder or a drill seeder.

The topsoil level will include a specified proportion of gravel. This coarser material will help protect the topsoil against erosion by forming an armoring layer. The topsoil will also have a specific pH range, minimal soluble salt content, specific gradation, and a proper balance of nutrients (e.g., nitrogen, phosphorus, and potassium) to encourage plant growth.

The estimated time to install the enhanced vegetative cover was based on an 8-hour work day using 18-cubic-yard haul trucks (15 cubic yards assumed capacity), and assumes that a portion of the materials will be stockpiled onsite prior to grading operations. Some schedule overlap of the placement of materials is expected. For example, the placement of clean fill can begin when a significant area of riprap, gravel, and geotextile has been placed.

II.2.3.3 Operation and Maintenance

A moderate level of long-term operation and maintenance (O&M) would be required with the enhanced vegetative cover alternative. Periodic visual observation would be used to detect any areas requiring repairs. Maintenance of the enhanced vegetative cover is expected to be fairly intensive in the short term, but long-term maintenance is expected to be minimal. Short-term maintenance would possibly include mulching to retain the seeding on the hillside, re-seeding of areas, and control of weeds. Long-term maintenance would include revegetation, and repairs of the cover due to excessive erosion or rodent and animal intrusion.

II.2.3.4 Site Restoration

Some portion of the surrounding terrain will be affected by construction operations. These areas would be revegetated or, at a minimum, restored to their original condition. Standard seeding equipment and materials and standard earthmoving equipment would be used for site restoration.

II.2.3.5 Institutional Actions

Deed restrictions and access restrictions for this alternative would be similar to those implemented for Alternative 2, (see Section II.2.2). The cover is expected to occupy approximately 4 acres. Radiological monitoring will be as described in Section II.2.2.

II.2.4 Alternative 4: Excavation and Disposal

Alternative 4 would involve the excavation of soils determined to be contaminated in excess of the remediation goals, continued radiological monitoring of the locations during excavation, and final sampling and analysis to confirm that the contaminated surface soils were completely removed. Transportation and disposal actions would isolate the contaminants from humans and the environment. Site restoration would be accomplished with the use of imported clean backfill and subsequent seeding of the exposed soils. The estimated duration for this alternative is 13 weeks. Figure II.2-3 presents the conceptual diagram for this remedial alternative. The following subsections detail the Alternative 4 components.

II.2.4.1 Site Preparation

Site preparation would include a survey of the site to determine the boundaries of the excavation. Such a survey would include a final estimate of the quantities to be removed to determine a basis for design and selection of excavation equipment. Preparations for haul routes, laydown areas, and staging areas would be made. Any required boundaries of an exclusion zone and the location of the decontamination area would also be determined. Prior to the initial breaking of ground, RFETS would confirm the location of any utilities that run through or near the site.

II.2.4.2 Excavation and Transportation

Excavation would consist of the removal of contaminated surface soils using such equipment as scrapers, bulldozers, front-end loaders, off-road haul trucks, and water trucks for dust suppression. The excavated soil would be transported to the onsite (that is within the boundaries of the RFETS) waste management facility for disposal. Operations at the onsite waste management facility would include accounting for the volume of soils being delivered and verification that the surface soil meets the waste acceptance criteria of the onsite disposal cell.

Dust suppression would consist of water addition to the surface soil during excavation operations. Water trucks with spray bars or spray-applied foams could be used to minimize dust production. Radioactive airborne particulates would be monitored during excavation operations to assess the effectiveness of the dust control measures and to ensure that exposure of workers is within acceptable levels.

Truck loading rates rather than excavation rates will control the duration of the excavation and disposal alternative. Truck loading rates are limited primarily by health and safety issues regarding inhalation of radioactive airborne particulates during the loading of the trucks.

Personal monitoring operations would be conducted during the start-up of excavation to determine if Occupational Safety and Health Administration (OSHA) Level D personal protective equipment is appropriate for the job. The safety level will impact the productivity rates of the excavation operations.

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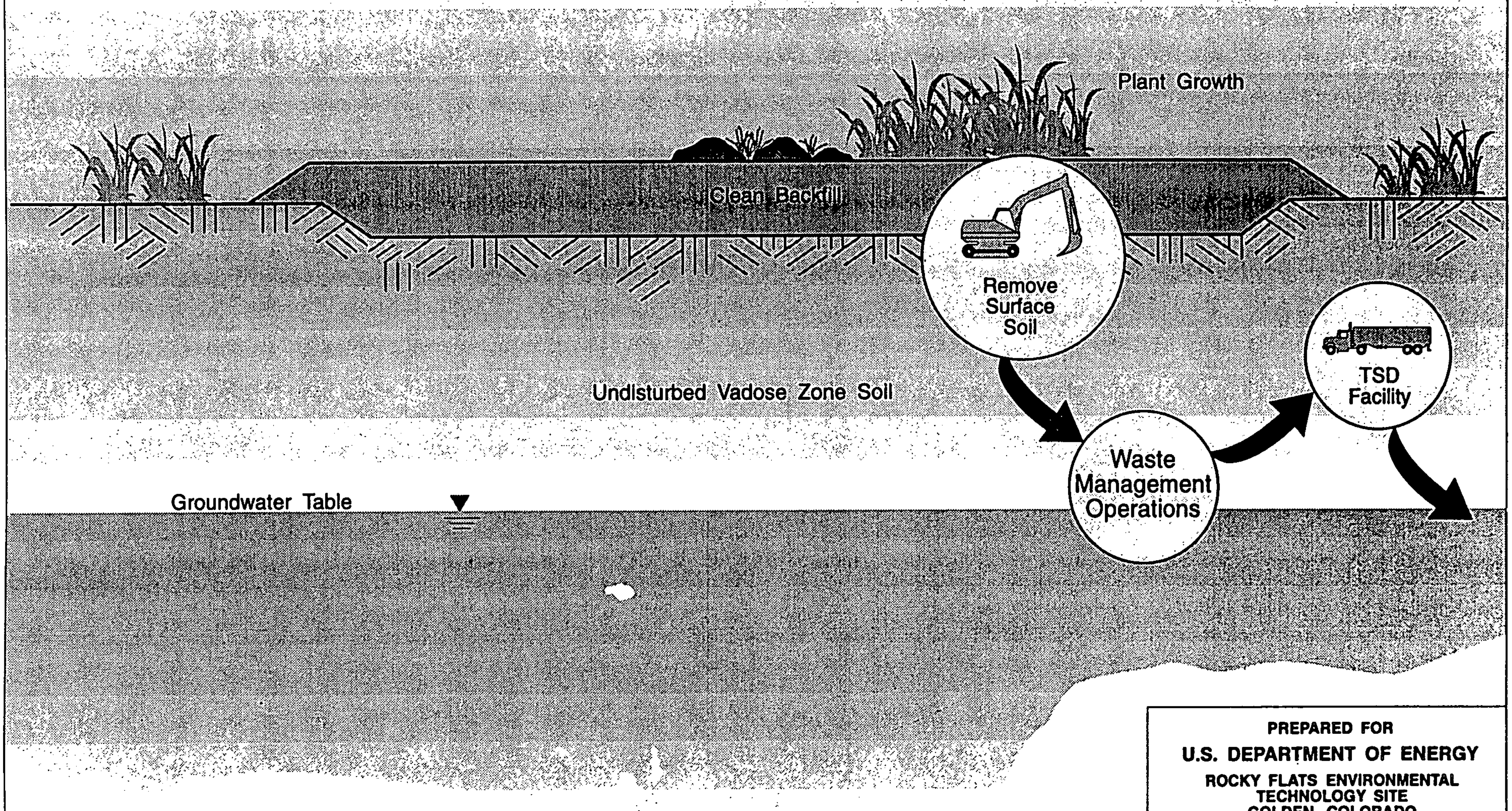

Note:
All contaminated surface soils are removed and the area is backfilled with clean soils.

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Figure II.2-3

Operable Unit No. 2
Interim Measure/Interim Remedial Action
Alternative 4
Excavation and Disposal

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The estimated time to perform this alternative is also based on equipment production rates, load and haul times, and the estimated trip durations to the onsite landfill. Time to complete backfill operations will depend on the length of the haul routes from the offsite clean borrow sources and the time required for the trucks to pass RFETS security. It is estimated that a maximum of one haul truck per 15 minutes should be expected.

II.2.4.3 Disposal

Onsite disposal options do not currently exist at the RFETS, but an onsite waste management facility is being designed and constructed. The site-wide waste management facility will be constructed by October 1996. The 903 Pad and Windblown Soils are expected to meet the onsite waste management facility waste acceptance criteria.

II.2.4.4 Sampling and Analysis

A sampling and analysis plan would be prepared detailing activities which will be conducted to demonstrate clean closure. A mobile laboratory equipped with analytical chemistry and alpha counters to measure plutonium and americium could reduce project analytical costs and expedite turnaround times. The mobile laboratory would be removed from the site following completion of the remediation. No long-term radiological monitoring of the remediated site should be necessary with this alternative.

A radiological survey program would be performed prior to excavation operations to determine the exact areas requiring excavation. After excavation activities were complete, confirmation samples would be taken to confirm that no contamination in excess of the remediation goals existed and that the site could be clean-closed.

II.2.4.5 Site Restoration

Site restoration would be performed with the placement of clean backfill in the excavated portion of the 903 Pad and Windblown Soils Area. Backfill should consist of clean soils that can be easily placed and are capable of supporting vegetative growth. If site restoration activities begin prior to the complete excavation of contaminated soils, the placement of clean backfill must be independent of excavation activities. Clean backfill should be imported to the site and stored in an independent laydown area prior to the start of backfill operations such that enough material is stockpiled to keep the earthmoving equipment busy.

II.2.5 Alternative 5: *Ex Situ* Treatment via Stabilization with Return to Excavation

This alternative consists of site preparation, excavation of contaminated surface soils, *ex situ* treatment using solidification/stabilization technology, site restoration including backfilling of the excavation using the treated soils, and revegetation of the disturbed areas. Radiological monitoring would be performed at the point of compliance to ensure that radioactive airborne particulates from the site were below prescribed remediation goals. It is expected that this alternative could be implemented within approximately 1 year, not including time needed for treatability studies. Figure II.2-4 presents the conceptual diagram for this remedial alternative. The following subsections describe the process options of Alternative 5.

II.2.5.1 Site Preparation

Site preparation activities for this alternative will be as described for Alternative 4.

II.2.5.2 Excavation

Excavation of the contaminated surface soils and confirmation sampling and analysis of the excavation will be as described for Alternative 4 (Section II.2.4).

II.2.5.3 *Ex Situ* Solidification/Stabilization

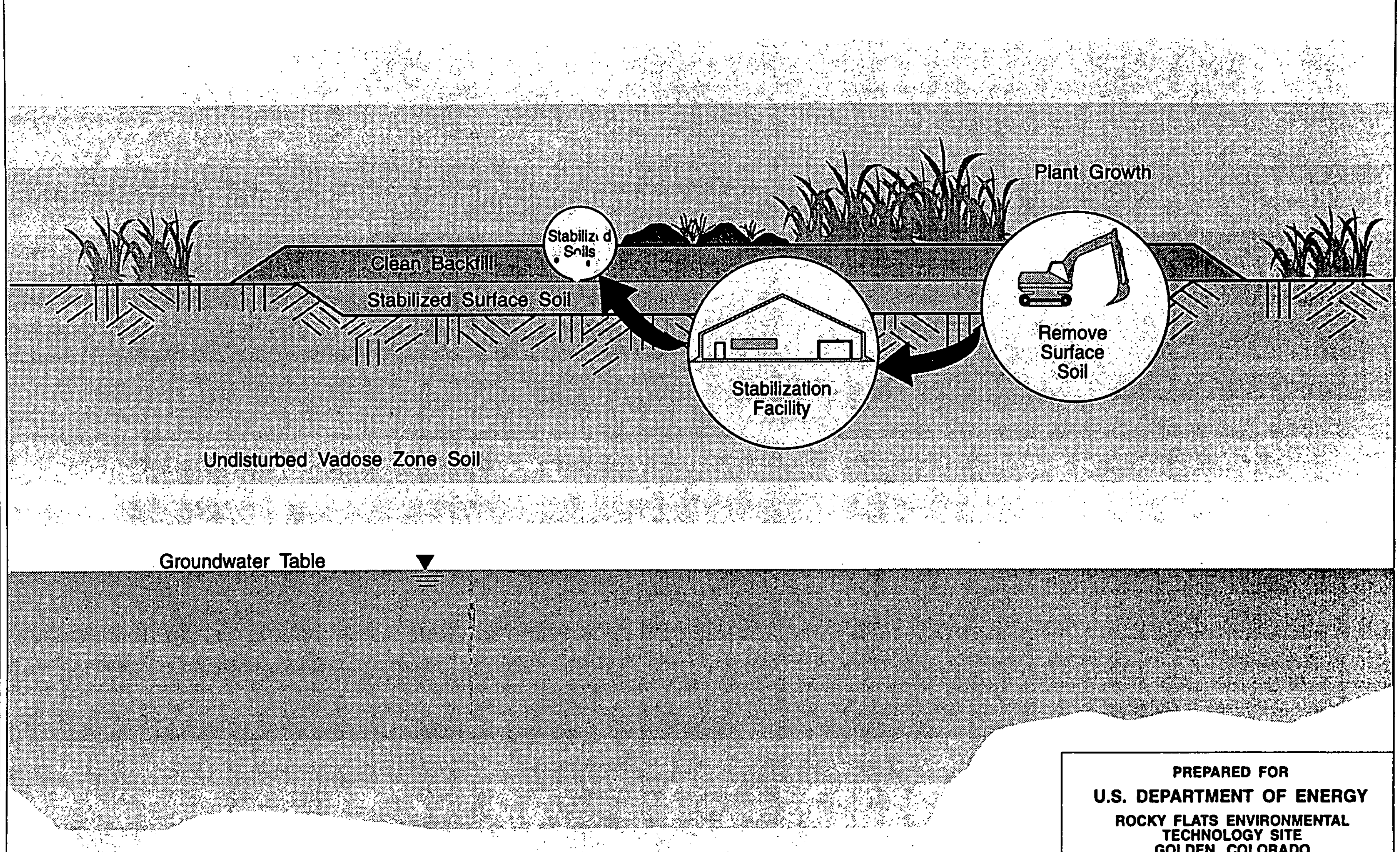
Initially, contaminated soils could be excavated and transported by truck to an onsite treatment facility. At the treatment facility, soils would be fed into a mixer and combined with stabilization reagents. Depending on the system used, one or more dry or liquid reagents would be added to the waste in the mixer. Actual mixing time would depend on the process, the batch size, and the types of reagents used. Afterward, the soil/binder mixture would be discharged or removed to an intermediate curing area or directly to a shipment staging area.

The treatment facility would be located to minimize the distance from the active excavation. A transportable system could be relocated as the remediation proceeded to various areas of the OU. Typical processing rates for a single mobile system can be as high as approximately 40 cubic yards per day, based on two operating shifts per day. Using this rate, it would take one mobile processing system approximately 1 year to process the 13,000 cubic yards from beneath the 903 Pad and the 3.1-acre contaminated area on the hillside.

Process reagents would be provided in mobile bulk trailers and smaller bulk containers, depending on the required quantities. Use of bulk trailers and containers would minimize the area required for processing. Required utilities typically would include electrical power at 480 volts of alternating current and 100 amperes, and process water at 10 gallons per minute, intermittent. Approximately 35 gallons of water per cubic yard of soil would be required, depending on the binder formulation.

II.2.5.4 Site Restoration

Site restoration would involve the placement of the stabilized soils and imported backfill in the excavated portion of the 903 Pad and Windblown Soils Area. After backfilling the stabilized soil, a shallow soil cover would be placed and seeded to establish an erosion-resistant surface cover. The backfill will consist of 2.5 feet of clean soils that are placed, contoured, and seeded to support vegetative growth.



Note:
All contaminated surface soils are removed for *ex situ* stabilization and returned to the excavation.

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ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

Figure II.2-4

Operable Unit No. 2
Interim Measure/Interim Remedial Action
Alternative 5
***Ex Situ* Treatment via Stabilization**
With Return to Excavation

II.2.5.5 Institutional Actions

Deed restrictions and access restrictions for this alternative would be similar to those implemented for Alternative 2 (see Section II.2.2). Radiological monitoring for both airborne particulates, ambient gamma-field monitoring, and surface water runoff would also be conducted as described in Section II.2.2.

II.3 DETAILED ANALYSIS EVALUATION CRITERIA

A detailed evaluation was conducted to select the preferred IM/IRA. The provisions contained in Section IX.C of the IAG were followed to perform the detailed analysis because the IM/IRA will be the final closure and remediation for the surface soils in this operable unit. The IAG selection criteria are consistent with the statutory mandates of CERCLA Section 121 and the nine evaluation criteria presented in the NCP. An explanation of the evaluation criteria used for the selection of the preferred IM/IRA is provided below.

The performance objectives in Section IX.C of the IAG require the IM/IRA to:

- Protect human health and the environment;
- Comply with ARARs unless a waiver is justified;
- Be cost-effective;
- Utilize permanent solutions and alternate treatment technologies or resource recovery technologies to the maximum extent practicable; and
- Address the preference for treatment as a principal element.

In assessing the remediation alternatives, the following items were considered:

- Long-term uncertainties associated with land disposal;
- Goals, objectives, and requirements of the Solid Waste Disposal Act;
- Persistence, toxicity, mobility, and propensity to bioaccumulate the hazardous substances and their constituents;
- Short- and long-term potential for adverse health effects from human exposure;
- Long-term maintenance costs;
- Potential for future remedial action costs if the alternative should fail; and
- Potential threat to human health and the environment associated with excavation, transportation, and redisposal or containment.

The nine evaluation criteria used to compare the various alternatives with respect to the above-mentioned performance objectives are listed in Figure II.3-1. Descriptions for each evaluation criterion are provided below.

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THRESHOLD CRITERIA	• Overall Protection of Human Health and the Environment • Compliance with ARARs
PRIMARY BALANCING CRITERIA	• Long-Term Effectiveness and Permanence • Reduction of Toxicity, Mobility, or Volume through Treatment • Short-Term Effectiveness • Implementability • Cost
MODIFYING CRITERIA	• Regulatory Agency Acceptance • Community Acceptance

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ROCKY FLATS PLANT
GOLDEN, COLORADO

Figure II.3-1

Operable Unit No. 2
Interim Measure/Interim Remedial Action
Evaluation Criteria

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Threshold Criteria

The following two threshold criteria are mandatory requirements that must be satisfied for an alternative to be selected.

(1) Overall protection of human health and the environment is the ability of an alternative to adequately eliminate, reduce, or control the chemical and radiological risks associated with each exposure pathway. The alternatives were assessed to determine both long- and short-term risks to human health and the environment. In this way, as low as reasonably achievable (ALARA) characteristics of each alternative could be compared. The radionuclide concentrations for a 15-mrem and 100-mrem annual exposure were established as the action levels for protecting human health. Compliance with this evaluation criterion is based on an alternative's ability to isolate the contaminated media in excess of the allowable concentrations so that human health and environmental exposures are eliminated.

(2) Compliance with ARARs is the ability of an alternative to satisfy the requirements specified in the ARARs. The alternatives were assessed to determine if the identified ARARs will be satisfied, or provide grounds for invoking a waiver. Table II.3-1 lists the potential location- and action- specific ARARs and TBCs for each alternative.

Primary Balancing Criteria

Primary balancing criteria are used to identify and compare the major tradeoffs among the alternatives. The balancing criteria allow the alternatives to be ranked and to determine the preferred IM/IRA. Balancing criteria include the following.

(3) Long-term effectiveness and permanence is the anticipated ability of an alternative to maintain reliable protection of human health and the environment over time, once the IM/IRA objectives are met. Alternatives were assessed to determine the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors that may be considered in this assessment include the magnitude of residual risk remaining from untreated waste or from treatment residuals of the remedial activities. The adequacy and reliability of controls necessary to manage treatment residuals and untreated waste, such as containment systems and institutional controls, were also considered.

(4) Reduction of toxicity, mobility, or volume through treatment is the anticipated performance of any treatment technologies. Alternatives which employ treatment were assessed for the degree that the alternative reduced toxicity, mobility, or volume of waste or residuals.

TABLE II.3-1
POTENTIAL LOCATION AND ACTION-SPECIFIC ARARs/TBCs FOR SOURCE AREAS FOR SURFACE SOIL CONTAMINATION

ARAR/TBC CITATION	REQUIREMENT DESCRIPTION	ALTERNATIVE				
		NFA[a]	Institutional Controls	Cap in Place	Excavate, Onsite Disposal	Excavate, *Ex Situ* Solidification/ Stabilization, Return
16 USC §§ 469 and 470 36 CFR 296 and 800 43 CFR 3 and 7 CRS 24-80-401 to 410	Historic and archeological preservation [b]	ARAR	ARAR	ARAR	ARAR	ARAR
16 USC § 661 *et seq.*	Fish and Wildlife Coordination Act	ARAR	ARAR	ARAR	ARAR	ARAR
16 USC § 668	Eagle Protection Act	ARAR	ARAR	ARAR	ARAR	ARAR
16 USC § 701-715 50 CFR 10	Migratory Bird Treaty	ARAR	ARAR	ARAR	ARAR	ARAR
16 USC § 1531 50 CFR 402 and 424 CRS 33-2-101 to 33-2-107	Evaluate federal projects for potential impact to endangered or threatened species or critical habitats	ARAR	ARAR	ARAR	ARAR	ARAR
50 CFR 17	Endangered and threatened wildlife and plants	ARAR	ARAR	ARAR	ARAR	ARAR
33 USC § 1344 10 CFR 1022 33 CFR 323	Evaluate federal projects for potential floodplain and wetland impacts [c]	ARAR	ARAR	ARAR	ARAR	ARAR
10 CFR 834 (Proposed)	DOE radiation protection requirements for public health and the environment [d]	TBC	TBC	TBC	TBC	TBC
DOE Order 5820.2A, Chapter III	Low-level radioactive waste management	---	---	TBC	TBC	TBC
10 CFR 835 DOE Order 5480.11	Occupational radiation protection standards [e]	---	ARAR	ARAR	ARAR	ARAR
29 USC §§ 657 and 667 29 CFR 1910	Worker protection requu :ments [f]	ARAR	ARAR	ARAR	ARAR	ARAR

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TABLE II.3-1 (Continued)

ARAR/TBC CITATION	REQUIREMENT DESCRIPTION	ALTERNATIVE				
		NFA[a/]	Institutional Controls	Cap in Place	Excavate, Onsite Disposal	Excavate, *Ex Situ* Solidification/ Stabilization, Return
29 USC § 668 DOE Order 5483.1A 29 CFR 1926	Occupational health standards for general construction activities [g/]	---	ARAR	ARAR	ARAR	ARAR
40 CFR 61, Subpart H 10 CFR 834 (Proposed)	NESHAP, radionuclide emissions	---	ARAR	ARAR	ARAR	ARAR
5 CCR 1001, Regulation 1	Fugitive particulate emissions [h/]	---	ARAR	ARAR	ARAR	ARAR
40 CFR 122.26 5 CCR 1002-3, 122.26	NPDES storm water management requirements	---	---	ARAR	ARAR	ARAR
40 CFR 262.11 6 CCR 1007-3, 262.11	Hazardous Waste Dete: ninations	---	---	---	ARAR	ARAR

a/ NFA = No further action.

b/ Although no historic or archeological sites are expected to be impacted, all federal actions are required to be assessed.

c/ Although no wetlands are expected to be impacted, all federal actions are required to be assessed.

d/ This regulation is proposed by the DOE to control radiation exposure for the protection of public health and the environment. Although the Nuclear Regulatory Commission (NRC) also has similar protection standards promu gated under 10 CFR 20.1301, the DOE regulation is identified as an ARAR for compliance purposes since the DOE regulation is consistent with the NRC stanc :ds and will be applicable to RFETS when promulgated.

e/ Although occupational worker standards are not considered ARARs/TBCs, the citation to the DOE radiation protection Program is being provided for completeness and to ensure that these protection requirements are not overlooked when preparing the implementation plans for the selected alternative.

f/ Although OSHA standards are not considered ARARs (see 55 FR 8680), 40 CFR 300.150 specifically requires that all response actions under the NCP maintain worker safety and health specified under 29 CFR 1910.120. This regulation is being listed for completeness and to ensure that these protection requirements are not overlooked when preparing the implementation plans for the selected alternative.

g/ Although OSHA standards are not considered ARARs (see 55 FR 8680), OSHA requirements would apply on their own merit. These OSHA standards apply to federal facilities as required by the Occupational Safety and Health Act (29 USC § 668) and Executive Order 12196; however, they are not independently enforced by OSHA. These occupational safety requirements are adopted and implemented under DOE Order 5483.1A. This regulation is being listed for completeness and to ensure that these protection requirements are not overlooked when preparing the implementation plans for the selected alternative.

h/ This standard would involve the control of fugitive particulates during regrading and/or excavation activities.

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(5) <u>Short-term effectiveness</u> is the time required to achieve the IM/IRA objectives and assess the adverse human health and environmental impacts resulting from implementation of the alternative. The alternatives were assessed to determine their short-term effectiveness by considering:

- Short-term risks that might be posed to the community during implementation of the alternative (i.e., ALARA concerns);
- Potential impacts on workers during implementation of the alternative;
- The effectiveness and reliability of protective measures;
- Potential environmental impacts of the alternative;
- The effectiveness and reliability of mitigative measures during implementation; and
- The time required to achieve protection.

(6) <u>Implementability</u> is the technical and administrative feasibility, and availability of materials and services required to implement an alternative. The alternatives were assessed to determine the ease or difficulty of their implementation by considering the following factors:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology;
- Reliability of the technology;
- Ease of undertaking additional remedial actions (if required); and
- Ability to monitor the effectiveness of the remedy.

(7) <u>Cost</u> is the amount of funds required to implement an alternative. The alternatives were assessed to determine capital costs, including both direct and indirect costs. The operating costs associated with treatment would likely be realized over a period of less than 1 year. Therefore, these operating costs were included as capital costs. Long-term, routine monitoring costs would be similar for the alternatives and were therefore addressed qualitatively.

<u>Modifying Criteria</u>

Modifying criteria reflect the concerns of the regulators and the community. These criteria will not be entirely known until the public comment period is over. These criteria will be considered, along with any new information, when preparing the responsiveness summary and may result in the modification of the preferred IM/IRA. Modifying criteria include:

(8) <u>Regulatory agency acceptance</u> is the ability of the preferred IM/IRA to address all of the concerns raised by the regulatory agencies. These include the agencies' positions and key concerns related to the preferred IM/IRA and other alternatives, and agency comments on compliance with the ARARs or the proposed use of waivers. These concerns are discussed in this decision document and will be considered during preparation of the responsiveness summary.

(9) Community acceptance refers to the public's general response to the preferred IM/IRA described in this decision document, including community support or opposition to the preferred IM/IRA. These concerns will be considered when preparing the responsiveness summary.

II.4 DETAILED ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives considered the relevant information and resulted in the selection of a remedial alternative for the 903 Pad and Windblown Soils IM/IRA. Individual alternatives were assessed against the evaluation criteria presented in Section II.3. A comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each evaluation criteria was also performed.

II.4.1 Individual Analysis of Alternatives

The following section presents an individual assessment and summary profile of each alternative against the evaluation criteria presented in Section II.3. Each alternative was evaluated against the threshold criteria which address overall protection of human health and the environment and compliance with ARARs. Alternatives that did not meet the threshold criteria were eliminated from further consideration. Alternatives which met the threshold criteria were then rated using the primary balancing criteria. The alternative was given a rating of low, medium, or high. High signifies the alternative meets all of the factors related to the criteria, while low signifies that the alternative only minimally meets the criteria.

II.4.1.1 No Further Action Alternative

II.4.1.1.1 Overall Protection of Human Health and the Environment

The no further action alternative would not adequately protect human health and the environment. This alternative would not be protective of human health and the environment because radioactive contaminants present in surface soil would not be reduced to the 15-mrem dose level for any of the exposure pathways.. The alternative was retained for comparison purposes only to allow the other alternatives to be ranked against a baseline.

II.4.1.1.2 Compliance With ARARs/TBCs

Although the no further action alternative is expected to comply with the location-specific and action-specific ARARs/TBCs listed in Table II.3-1, this alternative will not comply with chemical-specific TBC criteria identified for Pu-239/240 and Am-241. Even though the no further action alternative does not meet the threshold criteria, the primary balancing criteria were evaluated to provide a baseline comparison in accordance with EPA guidance (EPA, 1988).

II.4.1.1.3 Long-Term Effectiveness and Permanence

The no further action alternative will not meet the performance objective of the 15-mrem dose level. It will allow the potential migration of contaminants via surface water runoff, biota,

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and wind erosion. This alternative received a rating of *low* because it is not effective in decreasing the radiation dose associated with the site and is not considered a permanent solution.

II.4.1.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The no further action alternative does not include any treatment processes to reduce the toxicity, mobility, or volume of contaminated material. Contaminants will not be immobilized and can continue to migrate via wind dispersion, biota transport, surface water runoff, and other exposure routes. The no further action alternative is ranked as *low* because no treatment is provided to reduce the toxicity, mobility, or volume of contamination.

II.4.1.1.5 Short-Term Effectiveness

The risks to onsite workers and the community surrounding the RFETS will not change from current conditions with the implementation of the no further action alternative. No new or additional adverse environmental impacts are expected. However, continued uncontrolled contaminants in the surface soil may impact wildlife and surface water in the OU2 area. No mitigation measures or special controls will be implemented, and no direct or indirect effects will be caused by the implementation of the no further action alternative. This will not impact natural, historical and/or cultural resources. For this criterion the no further action alternative receives a *high* rating because there is not a significant impact to construction workers and the public from the implementation of this alternative.

II.4.1.1.6 Implementability

The no further action alternative is easy to implement and receives a *high* ranking for this criterion. A site-wide radioactive air monitoring program, which would be needed for this alternative, already exists. Additional ambient gamma field monitoring and surface water runoff sampling will be required. The no further action alternative will not impact any future remedial actions of subsurface soil and/or groundwater in the OU2 area.

II.4.1.1.7 Costs

Table II.4-1 provides a summary of the rough order of magnitude (ROM) cost estimate developed for each of the alternatives evaluated in the DAA. Back-up information for the cost estimate is provided in Appendix C. For the no action alternative, there are no capital costs. The annual O&M costs for sampling and analysis and site inspections are estimated to be $73,280. The present worth of this alternative is estimated to be $1,920,000.

II.4.1.2 Institutional Controls Alternative

II.4.1.2.1 Overall Protection of Human Health and the Environment

The institutional controls alternative is not protective of human health and the environment because the three exposure pathways would not be eliminated and radiation dose

TABLE II.4-1
OU2 IM/IRA DRAFT COST ESTIMATES FOR REMEDIAL ALTERNATIVES

	No Further Action	Enhanced Vegetative Cover	Excavation and Onsite Disposal	Excavation and *Ex Situ* Stabilization
Capital Costs				
Indirect Cost	$0	$246,600	$3,165,880*	$213,960
Direct Cost	$0	$756,936	$375,837	$3,319,274
OHD/Prft	$0	$219,313	$105,846	$457,232
Annual O&M	$73,280	$83,800	$0	$83,800
Present Worth O&M	$1,920,000	$2,179,556	$0	$2,179,556
Present Worth Total	$1,920,000	$3,402,400	$3,647,600	$6,170,000

* Includes onsite tipping fee

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levels would not be reduced to the 15-mrem dose level. Although the alternative may reduce the potential for humans to come in contact with the contaminants, the alternative would not reduce the radiation dose posed to human health and the environment or eliminate the following contaminant transport mechanisms: wind dispersion, surface water runoff, or biotic transport.

II.4.1.2.2 Compliance With ARARs/TBCs

The institutional controls alternative is expected to comply with location-specific and action-specific ARARs listed in Table II.3-1, but will not comply with chemical-specific TBC criteria identified for Pu-239/240 and Am-241. Existing residual soil concentrations for these radionuclides would remain onsite above dose-based remediation goals. The institutional controls alternative will not be further evaluated because it does not meet the threshold criteria.

II.4.1.3 Enhanced Vegetative Cover Alternative

II.4.1.3.1 Overall Protection of Human Health and the Environment

The enhanced vegetative cover alternative would reduce exposure to contaminated surface soil to an acceptable dose level (less than 15 mrem) eliminating ingestion, inhalation, and external exposure pathways. The alternative would be effective in both the short- and long-term for protection of human health and the environment.

II.4.1.3.2 Compliance With ARARs/TBCs

The enhanced vegetative cover alternative will comply with chemical-specific, location-specific, and action-specific ARARs and TBC criteria listed in Table II.3-1. No waivers and variances are anticipated.

II.4.1.3.3 Long-Term Effectiveness and Permanence

The enhanced vegetative cover alternative will meet performance objectives of the IM/IRA by containing the contaminated surface soils and blocking the potential contaminant transport mechanisms of biotic transport, surface water runoff, and wind dispersion. The geomembrane, gravel, and riprap layers would act as a biotic barrier to keep burrowing animals and roots from penetrating into the contaminated soils and prevent worms from migrating from the contaminated zone into the vegetative cover materials. Research results from the Los Alamos National Laboratory indicate that vegetative covers in semi-arid environments can be very effective at reducing infiltration of precipitation. This would reduce the potential migration of contaminants to the groundwater and reduce the potential for groundwater contamination. Snow melt is the primary concern in the RFETS region, and could reduce the effectiveness of this alternative during a short period each year. However, the expected frequency in conjunction with adequate design would not be expected to have a significant impact on groundwater recharge or quality.

This alternative is considered a permanent solution because the contaminated soils will remain onsite in a controlled environment. Land use restrictions will need to be incorporated into the RFETS-wide land use plan.

All long-term management, monitoring, and O&M, as discussed in Section II.2.3, will be performed with few difficulties and uncertainties because conventional post-closure care equipment and personnel are readily available. Cover failure due to catastrophic events such as an earthquake or flood is unlikely. The enhanced vegetative cover alternative is rated as *medium* for this criterion because it is effective in meeting performance specifications but still requires O&M.

II.4.1.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The enhanced vegetative cover alternative will reduce the mobility of the contaminants from wind dispersion, surface water runoff, and direct human contact. The cover will also reduce the potential for contamination migration via biota such as plants, burrowing animals, and earthworms. By limiting the infiltration of surface water, the cover will reduce the potential for contamination to migrate to the subsurface soils and groundwater.

Since the surface soils will not be treated, there will be no reduction in the toxicity or volume of contaminated materials. Therefore, this alternative is rated as *medium*. The mobility of the contaminants is reduced, but no treatment of contaminants is provided to reduce the toxicity or volume of contamination.

II.4.1.3.5 Short-Term Effectiveness

Radiation dose to the community from grading and construction of the enhanced vegetative cover will be minimal. Risks to onsite workers are expected to be minimal and can effectively be controlled through mitigative measures such as dust controls, use of personal protective equipment, limiting worker exposure durations, adhering to OSHA standards, locating and deactivating underground and aboveground utilities prior to excavation, and preparing and abiding by a health and safety plan. Administrative and engineering controls will mitigate release of radioactive airborne particulates during construction. Air monitoring will be performed during construction activities to confirm that the mitigation measures are effective. A contingency plan will be prepared for managing unexpected conditions.

The physical disruptions due to construction will temporarily limit the use of the 903 Pad and Windblown Soils Area. Vegetation, wildlife, and surface water may be temporarily disrupted due to traffic, changing drainage patterns, and soil erosion with the implementation of this alternative. Traffic controls, erosion control measures, and restoration of the remediated area should limit environmental impacts. Special controls for the protection of wetlands, flood plains, critical habitats, and endangered species will not be required.

Soil and materials used to construct the enhanced vegetative cover will be irreversibly and irretrievably committed. The indirect impacts from the construction of the vegetative cover will include a small, short-term increase in traffic; positive impact to the plants and animals living in the area; and a minimal impact to local hydrogeology. The enhanced vegetative cover alternative is rated *medium* because small temporary impacts to traffic, the site, and onsite workers will be experienced from the construction of the cover.

II.4.1.3.6 Implementability

The vegetative cover can be readily implemented based on the sloping grade of the site. No specific site conditions should reduce the implementability of this alternative. Only conventional construction methods and procedures are anticipated. Borrow sources for the soil required to construct the cover should be readily available onsite or locally offsite. No unique design attributes, materials, equipment, or construction techniques would be required. This alternative requires equipment and labor skills that are available in the Denver area. It should be acceptable to the regulators because it is effective, implementable, and has been proven at other sites in semi-arid environments.

The enhanced vegetative cover alternative can meet an expedited construction schedule. No treatability testing, or site-specific design studies will be required to implement the vegetative cover.

Construction of an enhanced vegetative cover limits access to subsurface soils and groundwater in the area that is covered. Future remedial activities of subsurface soil and/or groundwater may be adversely affected by the presence of a vegetative cover in the 903 Pad and Windblown Soils Area. The enhanced vegetative cover alternative receives a *high* ranking for implementability. The cover can be constructed with readily available equipment and materials with no need for treatability testing.

II.4.1.3.7 Costs

The estimated capital cost of the vegetative cover is approximately $1,222,850 for the 4.0-acre cover area. The O&M costs would be moderate due to periodic inspections and potential repairs of any erosional damage. Long-term air, radiological, and surface water monitoring would be required. Annual O&M costs are estimated to be $83,800 and the total present worth of this alternative is estimated to be $3,402,400. A summary of the cost estimate is provided in Table II.4-1. Appendix C provides the cost estimate details.

II.4.1.4 Excavation and Disposal Alternative

II.4.1.4.1 Overall Protection of Human Health and the Environment

Excavation and onsite disposal of contaminated surface soil would reduce surface soil to an acceptable dose level. The soil would be excavated and disposed to maximize short- and long-term effectiveness and to reduce risks to human health and the environment.

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II.4.1.4.2 Compliance With ARARs

The excavation and disposal alternative will comply with chemical-specific, location-specific, and action-specific ARARs and TBC criteria. No waivers and variances are anticipated.

II.4.1.4.3 Long-Term Effectiveness and Permanence

The excavation and disposal alternative will meet the performance objectives of the IM/IRA. Contaminated soil would be removed from the 903 Pad and Windblown Soils Area. Thus, the exposure pathways would be eliminated and radiation dose would be below remediation goals. Long-term management, monitoring, and O&M would not be required. The excavation and disposal alternative is rated as *high* because the contaminated soil would be removed from the site.

II.4.1.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The excavation and disposal alternative does not utilize treatment to reduce the toxicity, mobility, or volume of contaminated soil. The contaminated medium is removed from the 903 Pad and Windblown Soils Area, eliminating the risks at this area. The risks associated with the contaminated soils are transported to another location, where the ultimate reduction of mobility will depend on the effectiveness of the disposal facility. The alternative also will involve volume reduction through field sampling and soil segregation. This alternative is ranked as *medium* because no treatment of contaminants is provided to reduce the toxicity, however, mobility of contaminants and volume of contaminated soils would be reduced.

II.4.1.4.5 Short-Term Effectiveness

The short-term risk to the community from the excavation and disposal alternative would be minimal. Applicable controls, mitigation measures, construction worker risk, special controls, and temporary disruptions are similar to those discussed for the enhanced vegetative cover in Section II.4.1.3.5.

Materials that are irreversibly and irretrievably committed for this alternative will include fuels consumed during the collection and hauling of the contaminated soils, plus the space in the onsite landfill and the soils and materials used to construct the landfill. The indirect impact from the excavation and disposal alternative includes positive impacts to the plants and animals living in the 903 Pad and Windblown Soils Area, and a minimal impact to local surface water hydrology. No land use restrictions will be required. The excavation and disposal alternative is rated as *medium* because there will be a small short-term impact to traffic, the site, onsite workers, and the risks due to the transportation of contaminated materials.

II.4.1.4.6 Implementability

Future remedial actions of subsurface soil and/or groundwater in the OU2 area will not be impacted by the implementation of the excavation and disposal alternative. While issues may exist with respect to obtaining the necessary approvals and permits, they are not believed to be insurmountable. The low-level radioactive contaminated material could be stored in containers until the onsite disposal facility is ready. Required equipment and skilled workers for construction and operation of this alternative should be available. No constructability issues due to site conditions are anticipated.

Adequate onsite disposal capacity does not currently exist at RFETS. However, a site-wide waste management facility is currently being designed and permitted. This facility is scheduled to be ready to receive remediation wastes in October 1996. Implementability is contingent on regulatory approval for the onsite disposal facility. The 903 Pad and Windblown Soils program would be expected to demonstrate that the contaminated surface soils are in compliance with the site-wide waste management facility waste acceptance criteria. The excavation and disposal alternative is ranked *high* for implementability because it will be easy to implement (if the site-wide waste management facility is permitted and constructed).

II.4.1.4.7 Costs

Table II.4-1 provides a summary of the cost estimate for each alternative, and Appendix C provides back-up information for the cost estimate. Capital costs for the excavation and disposal alternative include costs associated with excavation, sampling, transportation, onsite disposal, and regrading with clean backfill. The capital costs are estimated to be $3,647,600. The excavation and disposal alternative would not incur any annual O&M costs, and therefore the total present worth of this alternative is $3,647,600.

II.4.1.5 *Ex Situ* Treatment via Stabilization with Return to Excavation Alternative

II.4.1.5.1 Overall Protection of Human Health and the Environment

This alternative was determined to be protective of human health and the environment. Radiation doses resulting from the ingestion, inhalation, and external exposure pathways would be reduced to acceptable levels. The alternative is effective in reducing short- and long-term risks to human health and the environment.

II.4.1.5.2 Compliance with ARARs

The *Ex situ* treatment via stabilization with return to excavation alternative is expected to comply with chemical-specific, location-specific, and action-specific ARARs, and TBC criteria. No waivers and variances are anticipated.

II.4.1.5.3 Long-Term Effectiveness and Permanence

This alternative will meet performance specifications of the IM/IRA by reducing the potential for contaminant migration and reducing exposure pathways. Confirmation samples will be taken during the entire processing period to ensure all stabilized materials meet quality assurance standards. The long-term use of the 903 Pad and Windblown Soils Area will not need to be restricted.

Stabilization has been proven to be effective at immobilizing metal contaminants in soils at full scale. Radioactive metal and metal oxide contaminants that occur in commercial nuclear power plant liquid and solid wastes have been successfully solidified and/or stabilized in the United States for shallow land disposal during the past three decades using cementitious binders, and more recently with bituminous binders. Bitumen has been commonly used for a longer time in Europe and Asia for these types of wastes. Cementitious and pozzolanic binders have been successfully used during the past decade for the solidification and stabilization of metal- and organic-contaminated hazardous wastes, including soils.

The commercially available stabilization processing equipment is considered reliable. O&M of the processing equipment will be required during treatment for this alternative. The *ex situ* treatment via stabilization and return to excavation alternative is rated as *high* because it is an effective and permanent solution.

II.4.1.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Stabilization will immobilize the contaminants in the soil to reduce mobility. However, stabilization will significantly increase the volume of contaminated material. The rating for this alternative is *medium* because *ex situ* stabilization will reduce the mobility of the contaminated soils, but it will increase the volume of contaminated material.

II.4.1.5.5 Short-Term Effectiveness

The risk to the community from the *ex situ* treatment via stabilization and return to excavation alternative is minimal. Applicable controls, mitigation measures, special controls and temporary disruptions are consistent with those for enhanced vegetative cover discussed in Section II.4.1.3.5. Dust controls will be provided to minimize fugitive air emissions to ensure protection of the community. *Ex situ* treatment of the contaminated surface soil will pose physical and chemical risks to onsite workers because exposure from process chemicals and potentially dangerous equipment could result during the handling and processing of the soils.

Clean backfill to cover the stabilized mass after treatment will be required to support vegetative growth. These materials, along with fuels and process chemicals, will be irreversibly and irretrievably committed. The indirect impacts from this alternative will create positive impacts to the plants and animals living in the 903 Pad and Windblown Soils Area and a minimal impact to local surface water hydrology. The alternative is rated as *medium* for short-term effectiveness because there will be temporary disturbances of the site and potential contaminant exposure to onsite workers.

II.4.1.5.6 Implementability

Treatability testing will be required to determine the best chemical binders. Additional considerations include throughput rate of waste, type of mixing equipment required, optimum size of the chemical feed system, matching the chemical feed system with the waste feed system, and utility and power requirements for the stabilization unit. Completion of these studies could impact the expedited construction schedule.

Treatment facility size can vary to suit the required processing rate. If desired, the equipment can be modularly arranged to facilitate mobilization between processing sites. However, generally as the facility size increases, the transportability of the system diminishes and becomes more complicated.

Typically, *ex situ* stabilization facilities have been operated in batch mode to accommodate the handling requirements of waste packages destined for offsite disposal. Customized *ex situ* treatment facilities have been designed to process certain DOE wastes continuously or in semi-batch mode. Process design for treatment of contaminated soils will need to consider the requirements of the final waste form, total processing time, and processing rate; logistics of moving the contaminated soil to the treatment facility or moving the treatment facility to specific areas of contaminated soils; and potential future use of the facility for other RFETS projects.

The previously mentioned considerations notwithstanding, an *ex situ* stabilization facility can be designed and implemented to process contaminated soils that would comply with all project requirements. Multiple systems would be anticipated, since the throughput of a single system of this nature is about 2 cubic meters per hour. Use of multiple small systems has the advantages of ease of transportation and processing rate versatility. The components of this system could be moved to various locations using a flatbed and/or fork truck. A modular system (or systems) with higher throughput could be designed and purchased, or leased to treat contaminated soils. This type of system would be moved by flatbed and/or crane and would involve more time to set up and tear down between operational sites than the smaller systems. A fixed plant may also be considered, but will involve semi-permanent or permanent allocation of real estate.

Reagents for use by a stabilization plant could be supplied through bulk trailers or containers. Containers for stabilized product, if used, will require a storage area near the processing site. Analytical laboratory services will be required for product quality control, and could be contracted or provided by existing RFETS facilities.

The placement of stabilized wastes on the surface of the 903 Pad and Windblown Soil Area may restrict future remedial actions of subsurface soil and/or groundwater in this area. The waste will need to demonstrate compliance to the waste acceptance criteria. This alternative is rated as *medium* for implementability because treatability testing and a longer implementation schedule are required.

II.4.1.5.7 Costs

Capital costs for this alternative include excavation, stabilization, transportation, backfill, and grading. The total capital costs are estimated to be $3,990,470 (Table II.4-1). Annual maintenance costs, which include site inspections and sampling and analysis, are estimated to

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be $83,800. Details of the cost estimate are provided in Appendix C. The present worth of this alternative is estimated to be $6,170,000.

II.4.2 Conclusions and Recommendations

The analysis determined that both the no further action and institutional controls alternatives should be eliminated from further consideration in the comparative analysis of alternatives because they did not meet the threshold criteria. However the no further action alternative will be included in the comparative analysis as a baseline. The remaining three alternatives are also considered in the comparative analysis: enhanced vegetative cover; excavation and disposal; and *ex situ* treatment via stabilization with return to excavation.

Each of the primary balancing criteria were analyzed and scored with respect to the sub-topics listed on Table II.4-2. Each alternative was scored with a value of 1 through 5 for each sub-topic. A value of 5 was assigned if an alternative achieved all of the requirements of the sub-topic and was considered to be the "best" alternative for the sub-topic. A value of 1 was assigned to an alternative if it did not meet the requirements of the sub-topic and was considered the "worst." Values of 2, 3, and 4, indicated how well an alternative met the requirements of a sub-topic in comparison to the other alternatives. A score of 5 equates to the "high" rating presented in Section II.4.1, and a score of 1 represents a "low" rating. A score of 2, 3, or 4 equates to a "medium" rating dependent upon a comparison between alternatives. The scores for each of the alternatives were then added to arrive at an overall score for each alternative. The alternative with the highest score was considered to be the most appropriate alternative for the contaminated 903 Pad and windblown soils. The following paragraphs provide the results of the comparative analysis for each of the primary balancing criteria. A summary of comparative analysis of alternatives is provided in Table II.4-3.

II.4.2.1 Long-Term Effectiveness and Permanence

The excavation and disposal alternative scored the highest (5) in all such topics because the contaminants are removed from the site. This results in complete blocking of the exposure pathways and elimination of residual risk. The enhanced vegetative cover and *ex situ* stabilization alternatives each received a score of 4 with respect to the mitigation of exposure pathways since both alternatives would block the exposure pathways. *Ex situ* stabilization received a score of 4 for the magnitude of residual risk, since the remaining contaminants are treated such that their potential mobility is reduced. The enhanced vegetative cover alternative received a score of 3 for this subtopic since the contaminants remaining in-place are not treated. It was determined that all of the remedial alternatives were equal (5) with respect to adequacy and reliability of monitoring and controls. The excavation and disposal alternative is considered to be a permanent solution (5), whereas under the enhanced vegetative cover, and *ex situ* stabilization alternatives, the contaminants would remain in place where they could, under failure conditions, provide a source of future contamination (score of 4).

The no further action alternative received the lowest scores (1) for the mitigation of exposure pathways, magnitude of residual risk, and permanence since contaminants would be left in-place untreated and uncontrolled. Based on the analysis of this criterion the alternatives

TABLE II.4-2
DETAILED SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

Evaluation Criteria	Remedial Alternative			
	No Further Action	Enhanced Vegetative Cover	Excavation and Disposal	*Ex Situ* Treatment With Stabilization Return to Excavation
Overall Protection of Human Health and the Environment	No	Yes	Yes	Yes
Compliance with ARARs	No	Yes	Yes	Yes
<u>Long-Term Effectiveness and Permanence</u>				
Mitigation of Exposure Pathways	1	4	5	4
Magnitude of Residual Risk	1	3	5	4
Adequacy and Reliability of Controls	5	5	5	5
Permanence	1	4	5	4
<u>Reduction of Toxicity, Mobility, or Volume through Treatment</u>				
Amount of Contaminant Destroyed or Treated	1	1	1	4
Expected Reduction in Toxicity, Mobility, and Volume	1	3	3	3
<u>Short-Term Effectiveness</u>				
Protection of Public During Construction	5	4	3	3
Protection of Onsite Workers During Construction	5	4	3	2
Time Until Remedial Actions are Complete	1	4	5	4
Environmental Impacts	5	4	3	2

TABLE II.4-2 (Continued)

Evaluation Criteria	Remedial Alternative			
	No Further Action	Enhanced Vegetative Cover	Excavation and Disposal	*Ex Situ* Treatment With Stabilization Return to Excavation
<u>Implementability</u>				
Technical Feasibility of Operation and Construction	5	5	5	4
Reliability of Technology	5	4	5	3
Availability of Services and Material	5	5	5	4
Affect on Future Site Remedial Actions	4	2	5	3
<u>Cost</u>				
Capital Cost	5	3	2	2
Annual Operation and Maintenance	3	3	5	5
Regulatory Acceptance	TBD	TBD	TBD	TBD
Community Acceptance	TBD	TBD	TBD	TBD
Final Score	53	58	65	56

NOTE: TBD = To be determined upon receipt of comments from the Regulatory Agencies and the community.

TABLE II.4-3
SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

Evaluation Criteria	Remedial Alternative			
	No Further Action	Enhanced Vegetative Cover	Excavation and Disposal	*Ex Situ* Treatment With Stabilization Return to Excavation
Overall Protection of Human Health and the Environment	No	Yes	Yes	Yes
Compliance with ARARs	No	Yes	Yes	Yes
Long-Term Effectiveness and Permanence	2	4	5	4
Reduction of Toxicity, Mobility, or Volume through Treatment	1	2	2	4
Short-Term Effectiveness	4	4	4	3
Implementability	5	4	5	4
Cost	4	4	4	3
Regulatory Acceptance	TBD	TBD	TBD	TBD
Community Acceptance	TBD	TBD	TBD	TBD
Final Score	16	18	20	18

NOTE: TBD = To be determined upon receipt of comments from the Regulatory Agencies and the community.

rank from highest to lowest were: excavation and disposal; *ex situ* stabilization; enhanced vegetative cover; and no further action.

II.4.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment

The no further action, enhanced vegetative cover, and excavation and disposal alternatives all scored the lowest value (1), since none of these alternatives destroy or treat any of the contaminants contained in the soils. The *ex situ* treatment alternative scored a 4 because, while it is the best, contaminants were only treated but not destroyed.

The enhanced vegetative cover, excavation and disposal, and *ex situ* stabilization alternatives all scored a value of 3 with respect to the expected reduction of toxicity, mobility, and volume. The enhanced vegetative cover and *ex situ* stabilization alternatives will reduce mobility, while the excavation and disposal alternative will reduce the volume of contamination.

The no further action alternative scored a 1 for both sub-topics because this alternative provides no reduction in toxicity, mobility, or volume. Based on the analysis of this criterion the alternatives from highest to lowest were: *ex situ* stabilization; excavation and disposal/ enhanced vegetative cover (equal); and no further action.

II.4.2.3 Short-Term Effectiveness

With respect to the protection of the public during construction, the no further action alternative scored the highest (5) because no construction activities would be performed. The enhanced vegetative cover scored a 4 because the least amount of contaminants would be excavated and exposed. The excavation and disposal, and *ex-situ* stabilization alternatives both received 3 scores because under these alternatives, the largest volume of contaminated soil would be excavated and exposed for potential airborne migration to public receptors.

With respect to the protection of workers during construction, the no further action alternative scored the highest (5) because there would not be any construction activities. The enhanced vegetative cover, excavation and disposal, and *ex situ* stabilization alternatives scored 4, 3, and 2, respectively due to the amount of excavation and the amount of contact between workers and the contaminants. The workers would have the most contact with contaminated materials under the *ex situ* stabilization alternative because of the excavation, contact during processing, and quality control testing of the treated product.

The excavation and disposal alternative would have the shortest period until the remedial action objectives are realized (5), followed by the enhanced vegetative cover (4) and *ex situ* stabilization (4) alternatives which have slightly longer (but equal) schedules. The no further action alternative scored the lowest (1) because under this alternative the remedial action objectives will not be realized.

With respect to the anticipated environmental impacts, the no further action alternative scored highest (5) because there will not be any construction activities. The enhanced vegetative

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cover alternative scored a 4 because the anticipated construction-related impacts would be minimal. The excavation and removal alternative scored a 3 because an excavation would be open for a short period during construction. The *ex situ* stabilization alternative received a score of 2 since the excavation would be open for the longest period (during treatment) and the treatment system may have slight environmental impacts. Based on the analysis of this criterion, the alternatives rank as follows: no further action/enhanced vegetative cover (equal); excavation and removal; and *ex situ* stabilization.

II.4.2.4 Implementability

With respect both to technical feasibility and availability of necessary services and materials, the no further action, enhanced vegetative cover, and excavation and disposal alternatives all received a score of 5. All of these technologies are commonly used throughout industry and at DOE facilities. The *ex situ* stabilization alternative received a score of 4 in these two sub-topics because although this technology is used throughout industry and at DOE sites, its effective operation is occasionally problematic and equipment is slightly more difficult to procure or fabricate.

In regard to the technology reliability, the no action and excavation and disposal alternatives score high (5) because these alternatives are proven effective. The enhanced vegetative cover alternative scored slightly less (4) in that engineered covers often have minor areas where failure occurs such as erosional problems or burrowing animals. The *ex situ* stabilization alternative received the lowest score (3) because there have been stabilization projects that have failed (i.e. OU4 pondcrete project) due to problems associated with quality control or scale-up from a pilot-scale to a full-scale treatment system.

With respect to the effect of the OU2 surface soil remediation on other future remedial actions, the excavation and disposal alternative rates the highest (5). This alternative would not adversely affect future remediation of other media and would not require that a future remedial action address surface soils.

The no further action alternative had a slightly lower score (4) since future remedial actions would not be obstructed, but remediation of surface soils may be necessary at that time. The *ex situ* stabilization received a score of 3 because the stabilized material could affect future remediation of subsurface soils or groundwater. The enhanced vegetative cover alternative received a score of 2 since it involves the largest volume of material that would need to be removed if it became necessary to gain access to the subsurface soils or groundwater for a future remedial action.

Based upon the analysis of this criterion, the ranking of alternatives from highest to lowest are: excavation and disposal; no further action; enhanced vegetative cover; and *ex situ* stabilization.

II.4.2.5 Cost

With respect to capital cost, the no further action alternative scores the highest (5) because no capital costs would be expended. The enhanced vegetative cover alternative received a score of 3 since its capital costs ($1.2M) are considerably more costly than the no further action alternative. The excavation and disposal ($3.6M) and *ex situ* stabilization ($4.0M) alternatives both received a score of 2 since they have costs similar to each other but are higher than the capital cost of the enhanced vegetative cover alternative.

For O&M costs, the excavation and disposal and *ex situ* stabilization alternatives received the highest score (5) since these alternatives would not require O&M expenditures. The no further action ($73K, $1.9M present worth O&M) and enhanced vegetative cover ($84K, $2.2M present worth O&M) alternatives would require monitoring since contaminated soils would be left in place. These alternatives would have similar monitoring requirements and similar costs. Both alternatives received a score of 3 since the costs would be significantly higher than the O&M costs associated with the other alternatives.

II.4.2.6 Regulatory Agency Acceptance

Regulatory agency acceptance of the selected alternative will not be known until after the public comment period.

II.4.2.7 Community Acceptance

Community acceptance of the selected alternative will not be known until after the public comment period.

II.4.3 Selection

Based on the results of the analysis of alternatives summarized in Table II.4-1, the DOE determined that the excavation and disposal of the contaminated surface soils in the onsite waste management facility should be the preferred IM/IRA for the 903 Pad and Windblown Soils. The excavation and disposal alternative is proposed for implementation since it will achieve or maximize the following IM/IRA objectives.

- Potential exposure to contaminated surface soils via direct contact, ingestion, and inhalation will be eliminated due to the removal of the contamination source.
- The alternative will meet the identified ARARs/TBCs.
- Future remediation alternatives for subsurface soil or groundwater (if necessary) at OU2 will not be adversely affected.
- The excavation and disposal alternative is consistent with the DOE goal of centrally locating contaminated media in a controlled and monitored, site-wide, waste

management facility rather than having numerous small OU-specific closure or remediation waste disposition areas.

- Generation of new waste requiring treatment and disposal will be minimized.
- The spread of contaminants during construction will be minimized.
- The alternative is cost effective based on a present worth analysis because long-term monitoring and maintenance are not required.

II.5 EXPLANATION OF SIGNIFICANT CHANGES

This section presents the functional and design requirements for the proposed alternative, and discusses the strategy for implementation.

II.5.1 Design Basis Functional Requirements

The following functional objectives have been identified for the proposed excavation and disposal alternative:

- The surface soil closure/remediation design shall remove contaminated surface soils to mitigate COCs such that established performance objectives and remediation goals are met.
- The gas detoxification building, Building 152 within IHSS 183 shall be removed.
- The remedial design shall prevent the erosion of surface soil during extreme precipitation events.
- The surface soils shall be remediated to control, minimize, or eliminate, to the extent necessary to protect human health and the environment, the release of regulated waste, constituents, leachate, or contaminated runoff to the surface water or the atmosphere.
- The excavation and disposal activities shall be conducted in a manner which minimizes exposure to environmental hazards.
- The excavation and disposal remedial action shall be designed to eliminate the migration of surface soil via airborne particulates, biotic transport, and surface water, and the need for long-term management, or maintenance.
- The closure/remediation design shall not impede any future remedial actions in the OU2 area.

- The closure/remediation design shall maintain accurate records for each truckload of contaminated soil including a manifest to document the proper classification of the material.

The following design criteria have been identified for the proposed alternative:

- The excavation and disposal action will provide a stormwater management system for dewatering and surface water control during construction.

- After the completion of the remedial activity, the site shall be graded to promote drainage to flow without eroding the surface soil.

- All excavated soil shall meet the waste acceptance criteria (WAC) of the site-wide wåste management facility.

- The excavated material shall be transported to the side-wide waste management facility in accordance with RFETS standards.

- The site-wide waste management facility is being designed under a separate project.

- Contaminated surface soils will be excavated until the concentration of soils is below remediation goals.

- Excavations shall be backfilled with clean imported backfill and regraded to natural topographic contours.

- The design for the remediation shall include specification of procedure to prevent the spread of contaminants to soil, water, or air during construction.

- The design shall include mitigation techniques to prevent airborne dust contamination during earthmoving, and waste transfer. Also, drainage control, stockpile coverage, and other measures, if required, including collection and treatment of stormwater, to prevent surface water contamination shall be implemented. The design shall include careful planning of stockpile management, earth-moving, and waste transfer to prevent soil contamination.

- The design shall meet all applicable requirements, as presented in Table II.5-1 for the following:

  Interagency Agreement (IAG) for the RFETS
  Federal regulations
  State of Colorado regulations
  DOE Orders and Directives
  RFETS standards and design criteria

II.5.2 Implementation Plan

Several steps are required to implement the selected remedial alternative, including the following:

- Perform radiological surveys in the areas to be excavated to identify the specific "hot spots" (concentrations exceeding remediation goals) requiring removal;

- Excavate "hot spots";

- Perform radiological surveys and sampling to confirm all contaminated soil was removed to below remediation goals;

- Complete excavation activities where required;

- Transport contaminated soil to proposed site-wide waste management facility;

- Backfill excavations with clean imported backfill;

- Regrade and seed affected areas; and

- Implement erosion control measures.

Table II.5-1 presents the ARARs for the selected alternative specifying the implementation strategy.

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TABLE II.5-1
IMPLEMENTATION OF ARARs FOR SELECTED ALTERNATIVE

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Location- Floodplain and Wetland Impacts	Federal agencies are to avoid construction within a floodplain or wetland unless there are no practical alternatives. If it is necessary to locate any of the remediation facilities within a floodplain or wetland, all practicable measures are to be taken to minimize any impacts to the floodplain or wetland. Actions must minimize destruction, loss, or degradation of wetlands, as defined by Executive Order 11990, Section 7. A floodplain or wetland assessment must be published in the Federal Register prior to taking any action within the floodplain/wetland to allow time for public review and comment. 10 CFR 1022 (CRS 25-12-101 to 25-12-108) (Applicable) 33 CFR 323 (Applicable) 33 USC § 1344 (Applicable) Executive Orders 11988 & 11990 [To be considered]	A wetland assessment will be prepared prior to construction activities. No floodplains have been identified in OU2. The preferred IM/IRA construction activities will avoid any floodplain areas. Therefore, a floodplain assessment does not need to be prepared and special precautions do not need to be established.
Location-Historic and Archeological Preservation	The Secretary of the Interior must be notified in writing whenever DOE finds or is notified in writing by an appropriate historical or archaeological authority that the activities in connection with a project may cause irreparable loss or destruction of significant scientific, prehistorical, historical, or archaeological data. Any data that may be lost or destroyed must be preserved by the DOE or the Department of Interior. 36 CFR 296 & 800 (CRS 20-80-401 to 410) [Applicable] 43 CFR 3 & 7 [Applicable] 16 USC §§ 469 and 470 [Applicable] DOE Environmental Compliance Guide (DOE/EP-0098) [To be Considered]	Historic or archeological sites will not be impacted as a result of implementing the preferred IM/IRA. Therefore, notifications and provisions to preserve artifacts are not required.

TABLE II.5-1 (Continued)

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Location - Endangered/Threatened Species Act	Practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. Taking is defined to include harassment, harm, pursuit, hunting, wounding, trapping, death, capture, or collection. Threatened or endang .ed species indigenous to Colorado should be protected to maintain and enhance their numbers. 50 CFR 402 & 424 (CRS 33-2-101 to 33-2-107) [Applicable] 16 USC § 1531 [Applicable] 50 CFR 17 [Applicable] 16 USC § 668 [Applicable] 50 CFR 10 [Applicable] 16 USC § 701 to 715 [Applicable' 16 USC § 661 [Applicable]	The American kestrel and the Preble's meadow jumping mouse have been identified in OU2. If the 1995 habitat study indicates the Preble's meadow jumping mouse forages or the American kestrel nests in areas of OU2 that will be disturbed during remedial activities, remediation plans for OU2 may be terminated or rescheduled. The bald eagle, which is a threatened species, has been spotted above RFETS. Bald eagles have not been known to inhabit or nest in OU2. If the 1995 habitat study indicates the bald eagle inhabits or nests in areas of OU2 that will be disturbed during remedial activities, the remediation plans for OU2 may be terminated or rescheduled.
Action, General - Public Health and the Environment	DOE Activities are to be conducted so that radiation exposures to members of the public are maintained below acceptable limits. This proposed regulation also addresses the management of real and personal property to control exposures to residual radioactive materials. DOE facilities have the capability, consistent with the types of operations conducted, to monitor routine and non-routine releases and assess doses. 10 CFR 834 (Proposed) [To be Considered]	Public exposure to radionuclides resulting from excavation activities will be calculated during the detailed design. Dust suppression measurements (i.e., water sprays, restriction of work during periods of high winds when fugitive particulate emissions are visible, etc.) will be employed as required to minimize radionuclide emissions. Air monitoring will be performed during field activities to ensure that all activities comply with the DOE's plan for prevention of contaminant dispersion (PPCD).
Action, General - Worker Protection	At DOE facilities, the radiation protection standards contained in 10 CFR 835 for occupational workers, unborn children, minors, and onsite members of the public shall not be exceeded. 10 CFR 835 [Applicable] DOE Order 5480.11, Section 9 [To be considered].	Occupational workers and onsite members of the public are required to wear dosimeters and personal protective equipment when entering a radiologically controlled area. Radiation monitoring is also required for all individuals exiting a radiologically controlled area. The personal protective equipment and monitoring will be used to ensure that occupational exposure limits are not exceeded; no additional controls are anticipated at this time. If monitoring during implementation of the preferred IM/IRA indicates a potential concern, additional work practices and engineering controls will be implemented. Details regarding the personal protective equipment and radiation monitoring requirements will be identified in the task-specific health and safety plan.

TABLE II.5-1 (Continued)

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Action, General - Worker Protection	The health and safety requirements provided in 29 CFR 1910.120 apply specifically to workers engaged in the handling of hazardous waste/materials at uncontrolled hazardous waste sites. Implementation of remedial activities is required to be conducted by OSHA-trained personnel and under OSHA requirements. All remediation employers are required to develop and implement a written safety and health program for their employees involved in hazardous waste operations. 29 USC §§ 657 and 667 [Applicable] 29 CFR 1910.120 [Relevant and Appropriate]	The preferred IM/IRA will be conducted in accordance with the provisions of this regulation. As required by 29 CFR 1910.129(b)(4), a task-specific health and safety plan will be prepared prior to the initiation of construction activities.
Action, General - Worker Protection	Federal agencies are required to establish and maintain an effective and comprehensive occupational safety and health program which is consistent with the standards promulgated under the Occupational Safety and Health Act. Specifically, 29 CFR 1926 Subpart P provides guidelines (including requirements for egress, safety, and protective systems) for workers engaged in activities related to excavations. 29 USC § 668 [Applicable] 29 CFR 1926 [Relevant and Appropriate] DOE Order 5483.1A [To be Considered]	A project-specific health and safety plan will be developed to implement the IM/IRA.
Action, General - Waste Determination	A person who generates a solid waste must determine if that waste is a hazardous waste using the procedures identified in 40 CFR 262.11. An overview of the hazardous waste determination procedures is presented in 40 CFR 260, Appendix I. 40 CFR 262.11 (6 CCR 1007-3, 262.11) [Applicable]	Any waste streams generated during the IM/IRA for disposal will be assessed for hazardous wastes by review of the OU2 RFI/RI data base, review of process/historical records, and sampling and analysis (as required).
Action, General - Air Discharges	Any owner or operator of land that has been cleared of greater than one acre in non-attainment areas from which fugitive emissions will be emitted shall be required to use all available and practical methods which are technologically feasible and economically reasonable to minimize such emissions in accordance with the requirements of 5 CCR 1001 - Regulation 1, Section III.D. The RFETS is located in a non-attainment area for particulates. 5 CCR 1001 - Regulation 1, III.D [Applicable]	Dust suppression measurements (i.e., water sprays, restriction of work during periods of high winds when fugitive particulate emissions are visible, etc.) will be employed as required to minimize fugitive particulate emissions. Air monitoring will be performed during field activities to ensure that all activities comply with the PPCD.

TABLE II.5-1 (Continued)

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Action, General - Air Discharges (Radionuclides)	Emissions of radionuclides to the ambient air from DOE facilities shall not cause any member of the public to receive an effective dose equivalent in excess of 10 mrem per year above background. This limit is based on an effective dose equivalent as calculated per the International Commission on Radiological Protection's Publication No. 26. 40 CFR 61, Subpart H [Applicable] 10 CFR 834 (Proposed) [To be Considered] DOE Order 5400.5 [To be Considered] DOE Order 5820.2A Chapter III [To be Considered]	Public exposure to radionuclides resulting from potential fugitive emissions will be calculated during the detailed design. Dust suppression measurements (i.e., water sprays, restriction of work during periods of high winds when fugitive particulate emissions are visible, etc.) will be employed as required to minimize fugitive particulate emissions and ensure public exposure is less than 10 mrem/yr. Air monitoring will be performed during field activities to ensure that all activities comply with the PPCD.
Action, General - Storm Water Management	Industrial facilities (as defined in 40 CFR 122.26) are required to submit an NPDES Stormwater Discharge Permit Application to US EPA by October 2, 1992. This permit application is to identify the sitewide monitoring program (including monitoring parameters and locations) for all storm water discharges. 40 CFR 122.26 (5 CCR 1002-3, 122.26) [Applicable]	If required, the sitewide NPDES permit will be modified prior to construction activities. All monitoring will be done in accordance with the NPDES permit.

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APPENDIX A

SITE CHARACTERISTICS AND ENVIRONMENTAL SETTING

SITE CHARACTERISTICS AND ENVIRONMENTAL SETTING
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A.1 DEMOGRAPHY AND LAND USE

The population, economics, and land use of areas surrounding the RFETS are described in a vicinity demographics report (DOE, 1990). This report encompassed an area within a 50-mile radius from the center of the RFETS and included all or part of 14 counties and 72 incorporated cities with a combined 1989 population of 2,206,500. The largest percentage of the population is located northwest, northeast, east, southeast, and south of the RFETS (refer to Section A.1.1). The current RFETS population consists of approximately 7,600 workers onsite. Land use within 0 to 5 miles of the RFETS is divided into urban and suburban residential, business/industrial, and open space/agricultural. Figure A-1 illustrates the current land use in the vicinity of the RFETS.

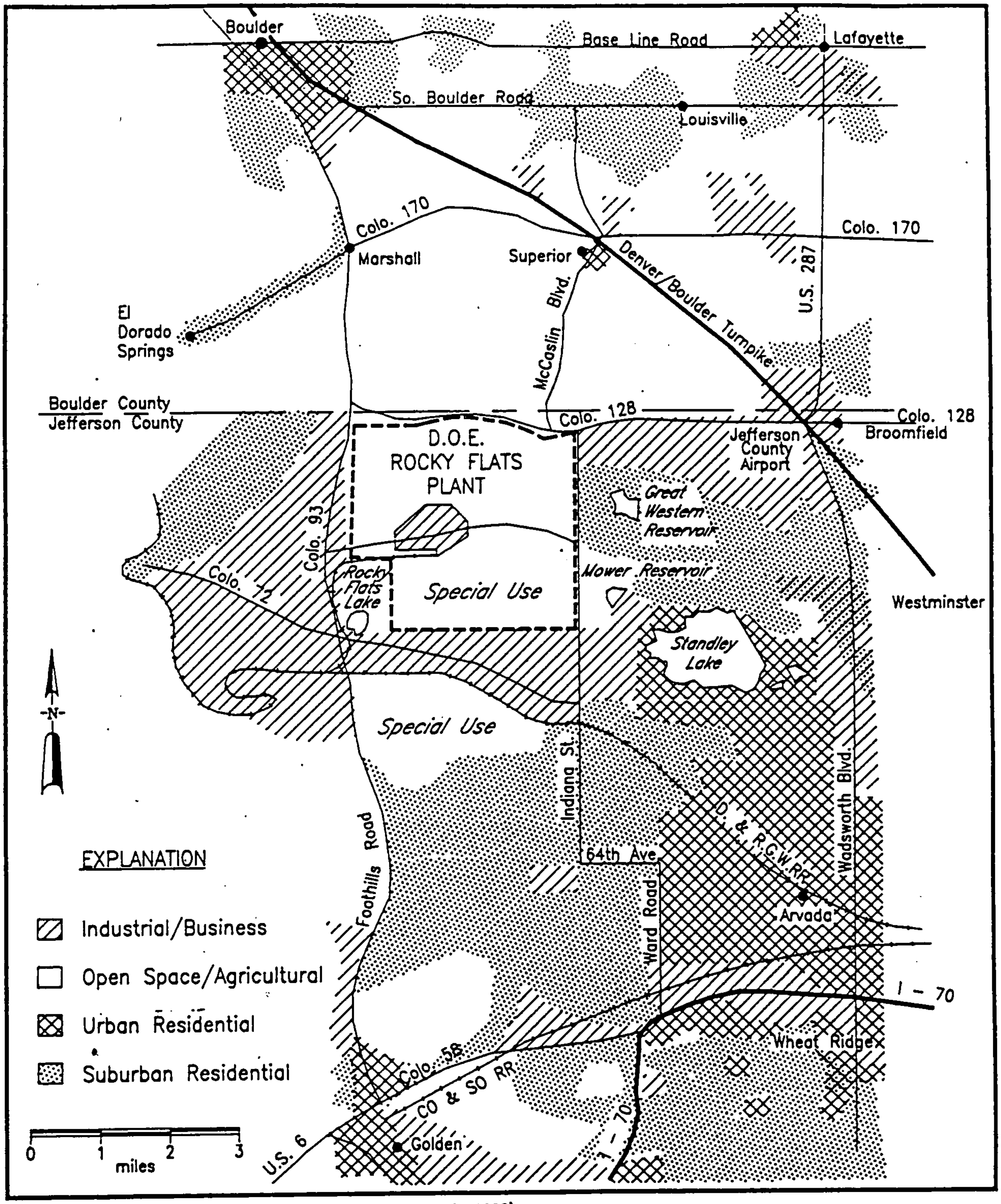
A.1.1 Current Land Use: Residential, Business, Industrial, Agricultural, and Open Space

The area west of the RFETS is mountainous, sparsely populated, and primarily owned by the U.S. Forest Service. The area east of the RFETS is generally a high, semiarid plain, densely populated, and primarily privately owned. Most of the population included in the 1990 DOE demographics report is located within 30 miles of the RFETS, primarily in the Denver metropolitan area to the east and southeast.

The majority of residential users within 5 miles of the RFETS are located to the northwest, northeast, east, southeast, and south of the RFETS. These population areas are divided into sectors related to distance from the RFETS and representing compass direction in Figure A-2. The actual 1989 residential population and projected population distribution within a 5-mile radius of the RFETS for the year 2010 are presented in Figures A-2 and A-3, respectively. The current population for Sectors 1 and 2 (the RFETS and adjacent areas) is zero, and projections for population growth indicate that the region will remain sparsely populated (zero growth is anticipated for the next 15 years) (DOE, 1990).

Most of Sector 3 and all of Sectors 4 and 5 are located outside the RFETS boundary and are therefore relevant to the offsite residential exposure scenarios. As discussed in Section A.1.2 (Future Land Use), these offsite regions are expected to experience significant population increases. (See Figure A-3.) The total 1989 population for Sector 3 was 51. Sectors 4 and 5 contain the majority of the 1989 population (9,072) within a 5-mile radius (DOE, 1990). Segments E through I on Figure A-2 lie in the predominant downwind directions from OU2 and represent the primary areas potentially affected by airborne contamination from the OU2 soils. (Refer to Section A.3 for wind direction discussions).

Approximately 316,000 people reside within a 10-mile radius of the RFETS. The largest residential development is located to the southeast, in the cities of Westminster, Arvada, and Wheat Ridge. The cities of Boulder to the northwest; Broomfield, Lafayette, Louisville, and Superior to the northeast; and Golden to the south also contain significant residential developments within this 10-mile radius (DOE, 1990).



(after: Jefferson County Planning and Zoning Department, April, 1990)

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Figure A-1

Operable Unit No. 2
Land Use in the Vicinity of the Rocky Flats Environmental Technology Site

Source: DOE, 1991d

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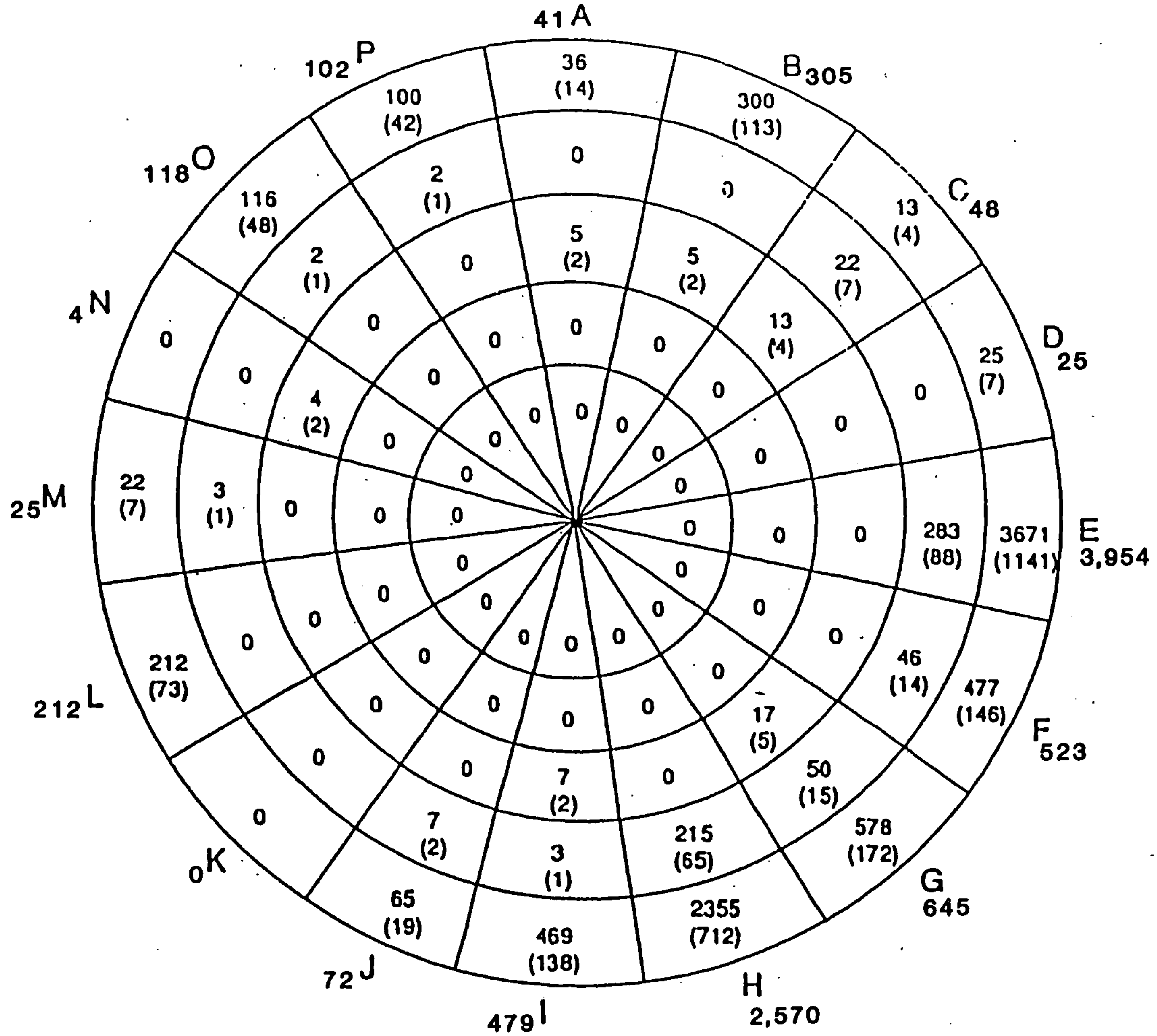

Miles from RFP Center	Sector Name	Population
0-1	Sector 1	0
1-2	Sector 2	0
2-3	Sector 3	51
3-4	Sector 4	633
4-5	Sector 5	8,439
	Total	9,123

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Figure A-2

Operable Unit No. 2
1989 Residential Populations and Households within a 5-mile Radius of the Rocky Flats Environmental Technology Site

Source: DOE. 1990. "1989 Population, Economic and Land Use Data for the RFP"

Note: The number of households is listed in parentheses for each population.

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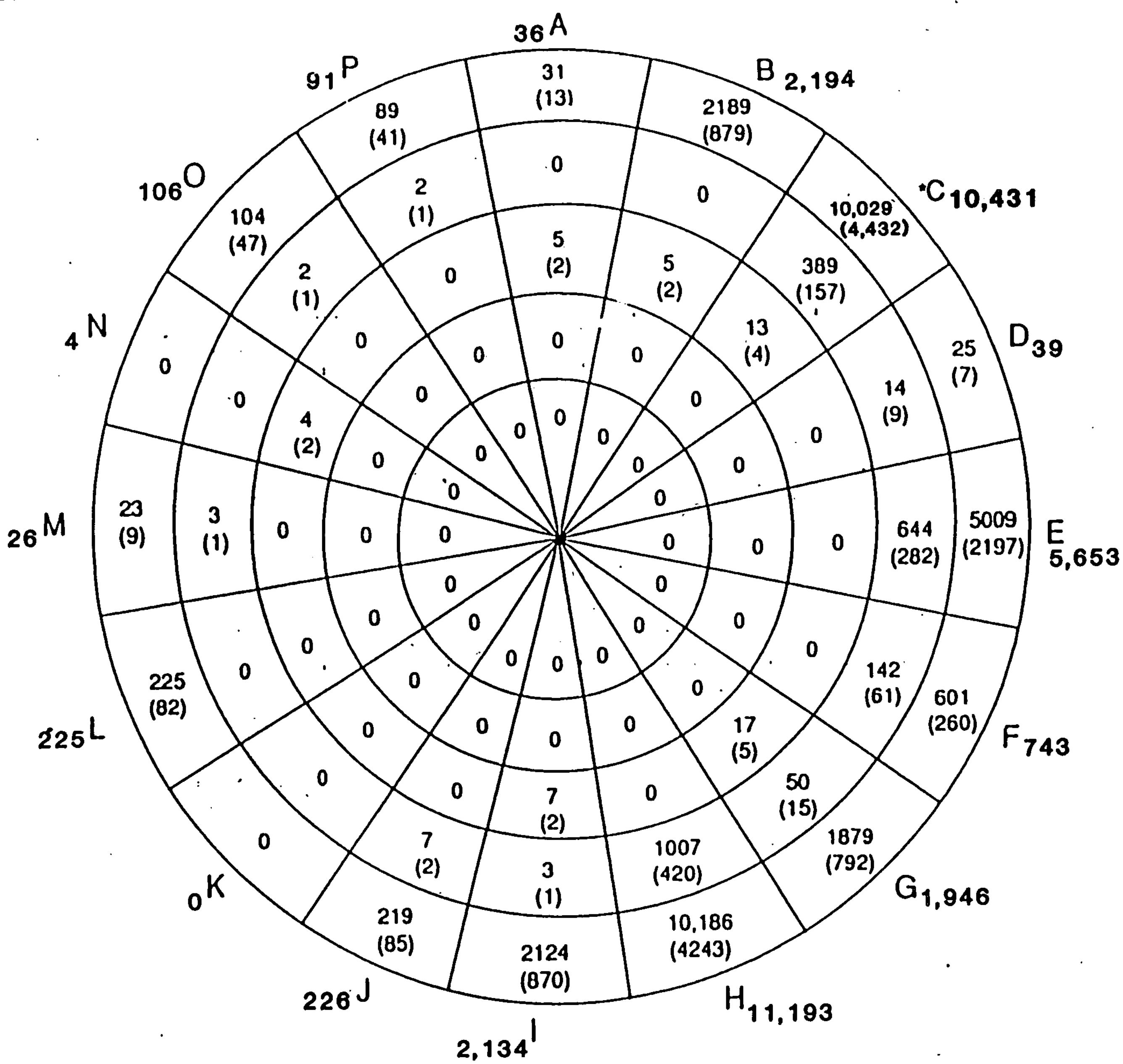

Miles from RFETS Center	Sector Name	Population
0-1	Sector 1	0
1-2	Sector 2	0
2-3	Sector 3	51
3-4	Sector 4	2,263
4-5	Sector 5	23,773
		Total 26,087

* Note: Segment C, Sector 5 - The "Population" and "Number of Households" values include the projected maximum number of occupancy permits to be issued for the Rock Creek housing development (4,000 by the year 2000)

*Source: City of Superior, 1994 DRCOG, 1994

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Figure A-3

Operable Unit No. 2
Year 2010 Expected Residential Population and Households within a 5-mile Radius of the Rocky Flats Environmental Technology Site

Note: The number of households is listed in parentheses for each population.

Source: DOE. 1990. "1989 Population, Economic and Land Use Data for the RFP"

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rl85x11h

Business/commercial development is concentrated near the residential developments around Standley Lake south and southeast of the RFETS, and near the Jefferson County Airport, approximately 3 miles northeast of the RFETS. Several small businesses are located to the south along State Highway 72.

Active industrial land use within 5 miles of the RFETS includes the following operations or activities: a sawmill and aggregate company to the north of the RFETS on State Highway 93; a sanitary landfill, a paving company, and a rock products company south of the RFETS on State Highway 93; and an analytical laboratory, a steel fabrication company, and a rock and dirt excavation company south of the RFETS on State Highway 72 (EG&G, 1991a). Active sand-and-gravel mines lie within the buffer zone boundaries (DOE, 1991d).

There are several inactive mining operations in the vicinity of the RFETS. Coal was mined in the region as recently as the 1950s (EG&G, 1992c). The Schwartzwalder Uranium Mine is located approximately four miles southwest of the RFETS. The mine was once the largest producer of vein-type uranium ore in Colorado and ranked among the largest of its type in the United States (DOE, 1980; DOE, 1991d). The mine was closed in 1989 (Colorado Division of Mines, 1992). Clay mining has occurred within the RFETS buffer zone in the past, but currently takes place outside of the facility boundaries (EG&G, 1992c).

Open space lands are located north and northeast of the RFETS near the city of Broomfield, in small parcels adjoining major drainages, west along the foothills, and as small neighborhood parks in the cities of Westminster and Arvada. Standley Lake to the east of RFETS is surrounded by Standley Lake Park.

Irrigated and nonirrigated croplands, producing primarily wheat and barley, are located northeast of the RFETS near the cities of Broomfield, Lafayette, and Louisville; north of the RFETS near Boulder; and in scattered parcels adjacent to the eastern boundary of the RFETS (DOE, 1992a). In 1987, according to Colorado agricultural statistics, 20,758 acres of croplands were planted in Jefferson County and 68,760 acres were planted in Boulder County. Other crops grown in the region include corn, dry beans, sugar beets, hay, and oats (Post, 1989). Irrigated corn and oats are grown north of the RFETS toward Louisville and east of the southern end of Boulder (EG&G, 1992c).

Livestock ranges are operated within 10 miles of the RFETS and are utilized to raise beef cattle, supply milk, and breed and train horses (DOE, 1991d). Several horse ranching operations and hay fields are located just a few miles south of the RFETS (DOE, 1992a).

A.1.2 Future Land Use

Future land use in the vicinity of the RFETS most likely will involve continued suburban expansion and increased density of residential and commercial land use in the surrounding areas. The expected trend in population growth in the vicinity of the RFETS is demonstrated by comparing the 1989 population data to population projections for the year 2010 (DOE, 1990).

The 21-year population-growth profile shows tripling of the population in the vicinity of the RFETS. The DOE estimates are based primarily upon long-term population projections developed by the Denver Regional Council of Governments (DRCOG). Expected population density and distribution around the RFETS in the year 2010 are shown in Figure A-3.

The only major, recent (post-1989 DOE population data) housing development within a 5-mile radius of the RFETS is the Rock Creek project in the city of Superior. To date, 530 occupancy permits have been issued for the project, with a maximum of 3,500 to 4,000 single- or multi-units expected to be constructed. This project should be completed by the year 2000 (City of Superior, 1994). The city of Superior does not expect any other significant growth in the area since most of the available land has been purchased for strictly open space use. DRCOG and the Jefferson County Planning and Zoning Department support this conclusion (DRCOG, 1994) (Jeffco, 1994).

Several areas of industrially zoned property are located adjacent to and near the RFETS. These properties are not likely to be developed in the near future due to the lack of water for fire protection. The properties must be admitted to a fire protection district prior to commercial or industrial development. To date, no fire protection district has been willing to accept the property, and it is anticipated that these properties will remain undeveloped in the near future (EG&G, 1992c).

A.1.3 Potentially Affected Human Populations

The current worker population at the RFETS is approximately 7,600. Most of these workers are involved in light industrial and commercial operations. In the near future, additional workers will be required for remediation and associated construction activities. These activities will range from the sampling of various media at the RFETS OUs to the construction of remedial structures.

The school closest to the RFETS is Witt Elementary School, approximately 2.7 miles east of the buffer zone (approximately 5 miles from the center of the RFETS) (DOE, 1991d). All other sensitive facilities, such as hospitals and nursing homes, are located beyond the 5-mile radius from the center of the RFETS. Ninety-three schools, eight nursing homes, and four hospitals are located within a 5- to 10-mile radius of the RFETS (EG&G, 1992c).

The nearest drinking water supply is the Great Western Reservoir, located approximately 2.3 miles east of the center of the RFETS. The city of Broomfield operates a water treatment facility immediately downstream from the Great Western Reservoir. This water treatment facility currently supplies drinking water to approximately 28,000 people. The continued use of the Great Western Reservoir as a drinking water source, however, is limited. The city of Broomfield has, with DOE's assistance, devised a plan to obtain drinking water from other sources distant from the RFETS. The city of Broomfield plans to have the alternative water supply selected and functioning by 1997.

Standley Lake Park is a recreational area and drinking water supply for the cities of Thornton, Northglenn, Westminster, and Federal Heights. The park is located 3.5 miles southeast of the RFETS. Water is piped from Standley Lake to each city's water treatment facility. Boating, picnicking, and limited overnight camping are permitted at Standley Lake Park. After 1997, Standley Lake will be the closest drinking water supply to OU2.

A.2 TOPOGRAPHY AND GEOMORPHOLOGY

The following sections briefly describe the topographical and geomorphological characteristics of OU2 and the RFETS in general.

A.2.1 Rocky Flats Environmental Technology Site General Characteristics

The RFETS is situated along the eastern edge of the central Rocky Mountain region immediately east of the Colorado Front Range. As shown in Figure A-4, the RFETS is at an average elevation of approximately 5,950 feet above mean sea level (ft msl). The site is located on a broad, eastward-sloping alluvial surface that has been deeply incised in some areas by modern drainage systems. Refer to Section A.4.1 for discussion of the drainage features. The surface of the alluvium slopes gently eastward at 88 feet per mile. The average elevation along the western RFETS boundary is 6,140 ft msl and slopes to about 5,700 ft msl along the eastern boundary.

A.2.2 Operable Unit 2 Site Characteristics

Section I.2 provides information with respect to the setting of OU2.

A.3 CLIMATOLOGY, METEOROLOGY, AND AIR QUALITY

The following two subparts of Section A.3 identify the site's climate, topography, impacts from wind, drainage, temperature, and air quality.

A.3.1 RFETS Climatology and Meteorology

The climate at the RFETS is strongly influenced by the Colorado Front Range. The region's semiarid climate is characteristic of much of the central Rocky Mountains. Dry, cool winters with some snow cover, and warm, relatively moist summers are typical.

Regional topography and upper-level wind patterns combine to create a semiarid climate along the foothills of the Colorado Front Range. Precipitation in the RFETS area occurs primarily as snowfall or short-duration thunderstorms. These localized thunderstorms are generally one hour or less in duration, and their areal extent is usually limited to approximately one square mile (ASI, 1991). Precipitation data are collected and recorded by EG&G at the West Buffer Zone Meteorological Station. The 1992 annual precipitation at the RFETS was 14.49 inches (EG&G, 1992b). The long-term average annual precipitation at the RFETS is

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approximately 16 inches. Although RFETS-specific evaporation data are limited, the annual net reservoir evaporation rate at RFETS is estimated to be 31 inches (EG&G, 1992b).

The orientation of the Front Range affects the local winds. Prevailing northwesterly winds are predominant at the RFETS and are normally channeled across the Rocky Flats pediment. High velocity winds have been recorded at the RFETS with the highest wind velocities occurring most frequently in the spring. Figure A-5 illustrates the RFETS wind frequency distribution for 1990-1991.

The RFETS is also affected by westerly drainage winds from the Front Range. These air flows, channeled through the Front Range canyons, are especially pronounced under conditions of strong atmospheric stability. Daily cycles of mountain and valley breezes also occur at the RFETS. North to south upslope air movement is also typical for the Denver area, with air flowing up the South Platte River Valley and entering the Front Range canyons. After sunset, the air cools as it contacts the mountain surfaces and moves downslope. Downslope flows converge with the South Platte River Valley flow and move toward the north-northeast.

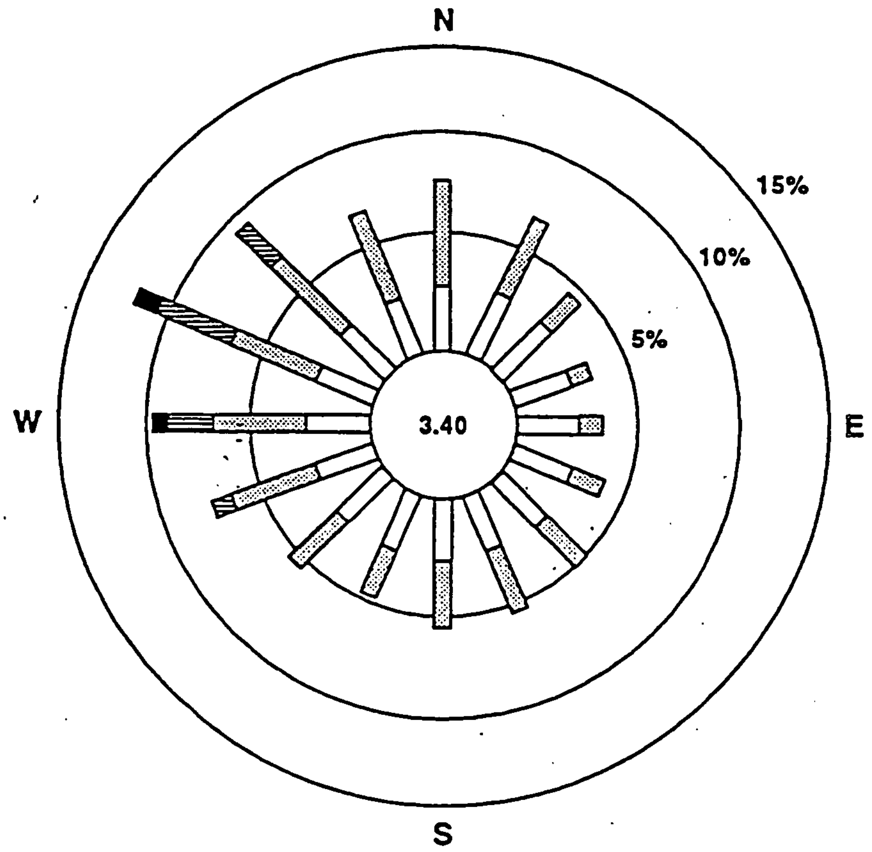
Strong surface air convections commonly produce thunderstorms during the summer, causing severe and locally unpredictable anomalies in normal air flows. Late winter and spring conditions can be influenced by chinook windstorms that move from west to east over the Continental Divide. Chinooks have been recorded in excess of 100 miles per hour (mph) at the RFETS (EG&G, 1992c).

The temperatures at the RFETS in 1992 averaged a maximum of 77 degrees Fahrenheit (°F) and a minimum of 18°F, with an annual mean temperature of 48.8°F. The recorded RFETS temperature extremes in 1992 ranged from 91°F in July to -4°F in January (EG&G, 1992b). The meteorological data were collected at the meteorological tower located in the northwestern buffer zone. Infrequent cloud cover over the region allows for intense solar heating of the ground surface. The low absolute humidity permits rapid radiant cooling at night. Relative humidity averaged 46 percent for the period from 1954 to 1976.

Special attention has been focused on the dispersion meteorology surrounding the RFETS due to the potential for significant atmospheric releases of contaminants affecting the Denver metropolitan area. Studies of air flow and dispersion characteristics indicate that drainage flows move toward the north and northeast along the South Platte River Valley to the west and north of Brighton, Colorado.

A.3.2 Air Quality

National Ambient Air Quality Standards (NAAQS) have been promulgated by the EPA in Title 40, CFR Part 50 for six pollutants, referred to as "criteria pollutants." The CDPHE's Air Quality Control Commission has adopted these standards for its compliance program. Areas of the state where concentrations of any of the criteria pollutants exceed the NAAQS are defined as "non-attainment" areas.



LEGEND

> 15 m/s	7 - 15 m/s	3 - 7 m/s	1 - 3 m/s	% Calm
> 34 mph	16 - 34 mph	7 - 16 mph	2 - 7 mph	

Source: 1991 Rocky Flats Plant Meteorological Data Base

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Figure A-5

Operable Unit No. 2
Annual Wind Rose for the
Rocky Flats Environmental
Technology Site, 1990-1991

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The Denver metropolitan region is considered to be a nonattainment area for the following criteria pollutants: carbon monoxide, particulate matter less than 10 microns (PM-10), and ozone. This nonattainment area encompasses all or parts of Adams, Arapahoe, Boulder, Douglas, Denver, and Jefferson counties. The RFETS is situated in the nonattainment area for all three pollutants.

Routine emissions of both radioactive and nonradioactive air pollutants have occurred from the RFETS, primarily during past operations. These operations were terminated in 1989, greatly reducing the emissions. There were only 12 Air Pollution Emission Notices (APENs - see Note [1] below) submitted to CDPHE in 1993, compared to over 200 in 1989 (EG&G, 1994). The RFETS emissions for nitrogen oxides are potentially greater than 100 tons per year (TPY). The industrial facilities discussed in Section A.2.1 are also potential sources of air pollution in the vicinity of the RFETS.

A.4 SITE AND LOCAL SURFACE WATER HYDROLOGY

Three streams, Rock Creek, Woman Creek, and Walnut Creek, drain the RFETS area and generally flow from west to east, as shown in Figure A-6. The major drainage basins receiving runoff from OU2 is South Walnut Creek. South Walnut Creek is an intermittent stream with flow occurring primarily after precipitation and snowmelt events. A description of these drainages is presented in the following section. Figure A-7 presents the routine surface water monitoring locations in the vicinity of the 903 Pad and windblown soil area.

A.4.1 Principal Drainage Basins

Rock Creek drains the northwestern corner of the buffer zone and flows northeastward through the buffer zone to its offsite confluence with Coal Creek. Coal Creek flows into Boulder Creek, St. Vrain Creek, and eventually discharges to the South Platte River. Rock Creek is peripheral to the RFETS.

Woman Creek, a stream originating west of the RFETS, drains the southern buffer zone and flows eastward, discharging into Standley Lake. Mower Ditch flows from Woman Creek in the eastern portion of the RFETS and supplies Mower Reservoir east of Indiana Street (EG&G, 1992e). The South Interceptor Ditch is located between the RFETS and Woman Creek, and collects runoff from the southern part of the RFETS and diverts it to Retention Basin C-2. Water from Retention Basin C-2 is pumped, treated (if necessary), and discharged in to the Walnut Creek drainage, where it flows offsite via the Broomfield diversion canal. Most of the remaining surface water runs off into the Woman Creek drainage south of the South Interceptor Ditch. Figure A-8 presents the extent of the 100 year floodplain for Woman Creek.

Walnut Creek is formed by the combined flows from North Walnut Creek and South Walnut Creek, which drain the central and northern areas of the RFETS, respectively. An

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Note 1: An Air Pollution Emission Notice must be submitted annually to the CDPHE Air Pollution Control Division for any and all sources of air pollution emissions. An APEN for new sources must be submitted prior to the release of any emissions.

unnamed tributary also drains the northern part of the RFETS. OU2 is drained primarily by the South Walnut Creek tributary. The three Walnut Creek tributaries join in the buffer zone to form Walnut Creek, which flows eastward to the Great Western Reservoir. However, flow in Walnut Creek is generally diverted around the Great Western Reservoir into Big Dry Creek through the Broomfield Diversion Ditch. Figure A-9 presents the extent of the 100-year floodplain for South Walnut Creek.

A.4.2 Surface Water Control Structures

Surface water management controls are in operation at RFETS. The West Interceptor Trench diverts runoff from the headwaters of North Walnut Creek via the McKay Ditch Bypass to Walnut Creek west of Indiana Street. In addition to ditches and canals, a series of retention ponds has been constructed to control the release of RFETS discharges and to collect surface water runoff.

South Walnut Creek begins in the RFETS and receives runoff from OU2. Runoff in South Walnut Creek is collected in Retention Basins B-1 through B-5. The runoff flows overland into the portion of the drainage that is within the Protected Area. The runoff enters a culvert system under the Northeast Perimeter Road and flows into a diversion structure located just upstream from Basin B-1. This runoff is normally diverted around Basins B-1, B-2, and B-3 through a bypass line to Basin B-4, although it can be diverted into Basin B-1. Basin B-4 has limited storage capacity and generally passes water directly to Basin B-5.

Basins B-1 and B-2 are spill control ponds that receive water from the South Walnut Creek basin. Water in Basins B-1 and B-2 is kept at low levels in order to maintain capacity for spill control for the sewage treatment plant (STP). Basin B-3 is discharged to Basins B-4 and B-5 in accordance with the provisions of the NPDES permit. Basin B-5 is the terminal pond on South Walnut Creek. Water from Basin B-5 was historically treated and discharged to South Walnut Creek. Currently, excess water in Basin B-5 is transferred by a new pipeline to Basin A-4, where it is treated (if necessary) and discharged to North Walnut Creek according to the NPDES permit, the FFCA, and the AIP.

A.4.3 Seeps

Seepage resulting from the discharging ground water has historically been observed on the OU2 hillside. Seeps occur at the interface of the Rocky Flats Alluvium and the Arapahoe Formation. Seepage areas commonly appear to be moist or wet, even though precipitation has not recently occurred. These areas may or may not be marked by the presence of phreatophytes (plant species with roots that extend to the water table). The seeps are not normally point sources of overland flow, and flow rates have not been estimated. Visual observations suggest that most of the seepage currently evaporates or transpires.

A.5 SITE AND LOCAL SOILS

Three types of soil have been described by the Soil Conservation Service (SCS) (1983) at the RFETS. These soil types are designated as the following: the Flatiron Series, located on the Rocky Flats Alluvium; the Nederland Series, commonly located on the upper slopes flanking the Rocky Flats Alluvium; and the Denver-Kutch-Midway Series, located on slopes flanking the Nederland soils. All of these soil series have been identified in the OU2 area (SCS, 1983). Figure A-10 presents a diagram of the various soils located within and around the RFETS.

The Flatiron Series is a cobbly, sandy loam that exhibits a slow infiltration rate and is located on slopes of 0 to 3 percent. The Denver-Kutch-Midway Series is a clay loam, also exhibiting a slow infiltration rate, and develops on the Arapahoe Formation claystones where slopes range from 9 to 25 percent. The Nederland Series develops adjacent to the Flatiron Series along the periphery of the Rocky Flats Alluvium where slopes range from 15 to 50 percent. The Nederland Series soil exhibits a moderate infiltration rate. All three soil types are partially obscured by fill materials, gravel, or buildings and other structures.

A.6 REGIONAL AND LOCAL GEOLOGY

Significant work has been conducted recently to further characterize the geology at the RFETS. A Geologic Characterization Report for the entire RFETS (EG&G, 1991c) was prepared based on a comprehensive literature search, and describes previously obtained core samples, reprocesses previously obtained seismic data, and analyzes select samples for grain size distribution. A summary of the results of this study, as they pertain to OU2, is presented in the following sections.

A.6.1 Regional Setting

The current structural setting of the central Rocky Mountain region is dominated by the subsidence of large basins and the rise of extensive uplifts, such as the Denver Basin and Front Range. For at least the second time, the Front Range area has risen from below sea level to several thousand feet above sea level. This tectonic event occurred during the Laramide Orogeny, approximately 70 to 65 million years ago. Concurrently, the adjacent Denver Basin began and continued to subside to its current structural relief of at least 16,000 feet, measured from the basin bottom onto the flank of the Front Range, a distance of only a few miles.

The Laramie Formation is the youngest pre-Laramide Orogeny sediment package. It is interpreted as a coastal plain deposit and records sedimentation prior to the uplift of the Front Range and subsidence of the Denver Basin. The Laramie Formation consists of alternating yellowish-gray sandstones, varicolored kaolinitic claystones, and siltstones with subbituminous coal beds in the upper part. Laramide sediments, which lie above the Laramie Formation, comprise the Arapahoe and Denver Formations. The Arapahoe Formation, exposed along the Front Range west of Denver, consists of a lower cross-bedded conglomeratic sandstone sequence

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and an upper sequence of dark gray claystones and mudstones with thin layers of siltstone and sandstone. The lower conglomeratic sandstone sequence is not ubiquitous, and is generally not present at the RFETS. The Arapahoe Formation lies unconformably upon the Laramie Formation and is thought to have been deposited in braided-stream and channel-margin environments.

Structurally, the RFETS is located on the western flank of the Denver Basin, approximately 4 miles east of steeply dipping strata on the eastern flank of the Front Range. West of the RFETS, older sedimentary formations and the Laramie Formation claystones dip approximately 50 degrees to the east. Beneath the RFETS, bedrock flattens to a dip of approximately 3 degrees.

The RFETS is located on a broad, undulating, eastward-sloping pediment surface along the western edge of the Denver Basin. Geologic units beneath the RFETS consist of unconsolidated surficial units including the Rocky Flats Alluvium, younger terrace alluvium (Verdos, Slocum, and Louviers Alluvia), valley fill alluvium, and colluvium (Figure A-11). These unconsolidated surficial deposits are unconformably underlain by approximately 10,000 feet of Pennsylvanian to Late Cretaceous sedimentary rocks that have been locally folded and faulted, as shown in Figure A-12. Figure A-13 presents a generalized stratigraphic section of the Denver Basin bedrock formations. Figure A-14 shows a stratigraphic section of the RFETS.

A.6.2 Operable Unit 2 Area Geology

Surficial Geology

Surficial geologic units within OU2 consist of alluvial, hillslope, and man-made deposits. Alluvial deposits include the Pleistocene-aged Rocky Flats Alluvium, younger terrace alluvia, and various Holocene-aged valley-fill alluvia. Hillslope deposits consist of Holocene-aged colluvium and landslide slumps. Man-made deposits are artificial fills, debris dumps, and areas of disturbed surficial soil. A brief summary of the surficial deposits is presented below.

The Rocky Flats Alluvium is the topographically highest and oldest alluvial deposit at RFETS. The Rocky Flats Alluvium within OU2 caps the pediment surface between South Walnut and Woman Creeks. The pediment is completely truncated to the north, east, and south by these modern drainages. The Rocky Flats Alluvium within the OU2 area consists predominantly of beds and lenses of poorly to moderately sorted gravels and sands. A few lenses of clay and silt also occur.

Hillside deposits within the OU2 area include several alluvial terrace deposits, valley-fill alluvium, colluvium, and landslide slumps. Slump features belong to two categories: 1) areas along the hillsides which exhibit evidence of mass movement of surficial soil and possibly bedrock materials along relatively distinct ruptures or glide surfaces, and 2) areas of hummocky topography reflecting downslope creep of surficial soils but no observable rupture surface.

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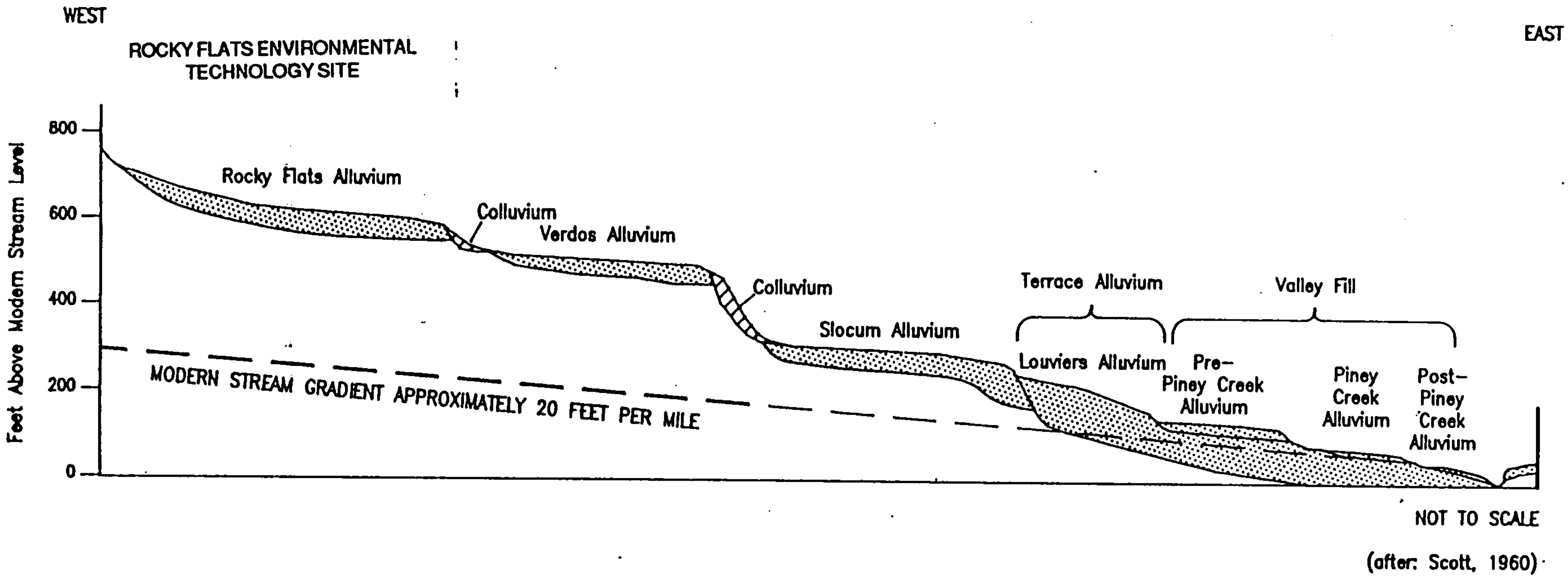

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Figure A-11

Operable Unit No. 2
Erosional Surface and Alluvial Deposits
East of the Front Range, Colorado

Source: EG&G. 1991. " Draft Final Geologic Characterization Report for the RFP"

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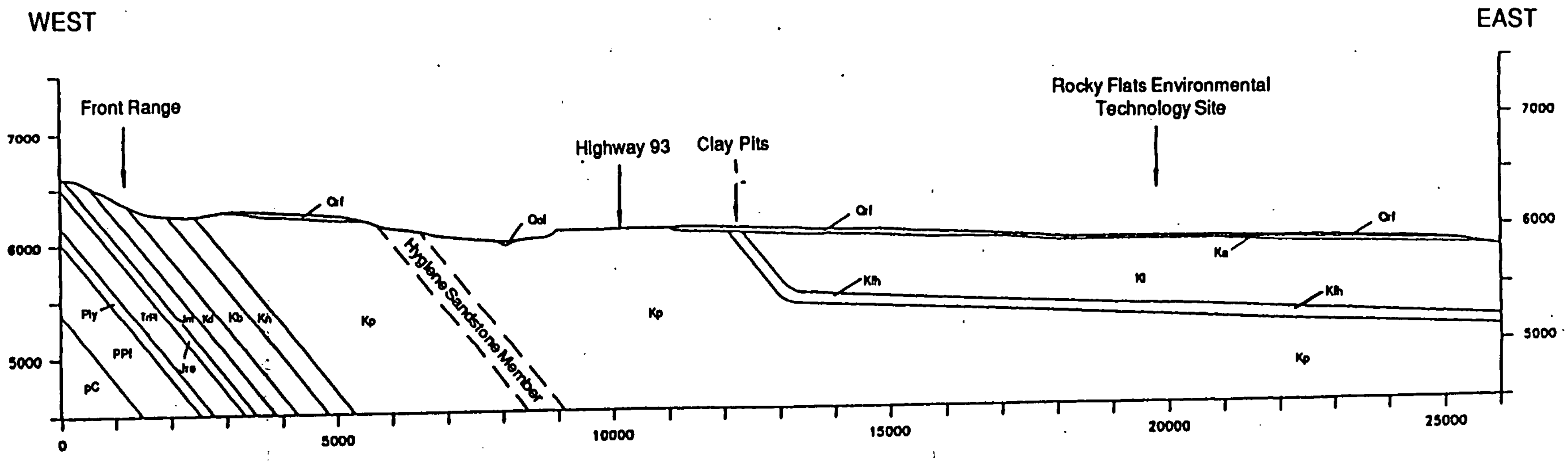
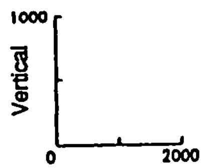


EXPLANATION

Qrf = Quaternary Rocky Flats Alluvium
Qol = Quaternary Valley Fill Alluvium
Ka = Cretaceous Arapahoe Formation
Kl = Cretaceous Laramie Formation
Kfh = Cretaceous Fox Hills Sandstone
Kp = Cretaceous Pierre Shale
Kn = Cretaceous Niobrara Formation
Kb = Cretaceous Benton Shale
Kd = Cretaceous Dakota Group
Jm = Jurassic Morrison Formation
Jrc = Jurassic Ralston Creek Formation
TrPl = Perma-Triassic Lykins Formation
Ply = Permian Lyons Sandstone
PPf = Pennsylvanian-Permian Fountain Formation
p€ = Precambrian



Horizontal
Scale in Feet
2x Vertical Exaggeration

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Figure A-12

Operable Unit No. 2
Generalized West-East Cross-Section
Front Range to the Rocky Flats Environmental Technology Site

Modified from: Hurr, 1976

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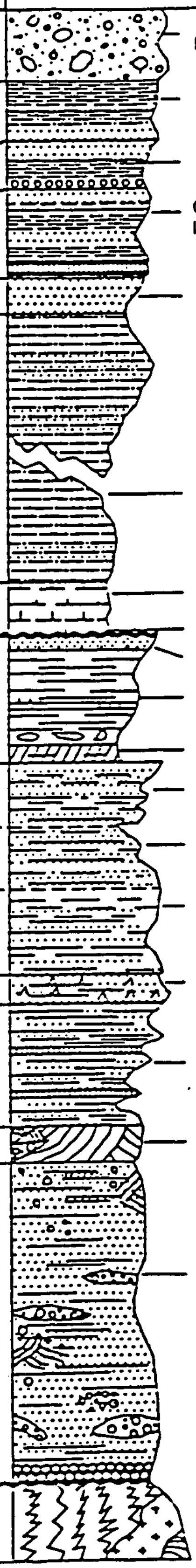

AGE	FORMATION	Thickness (Feet)	GRAPHICS	SUMMARY DESCRIPTION
TERTIARY	Green Mountain	600'		Boulder conglomerate with occasional thin siltstone lenses
TERTIARY	Denver	870'		Yellowish-brown to grayish-olive fluvial tuffaceous claystone, siltstone, and sandstone interbedded with conglomerate and olive-gray mudflows
UPPER CRETACEOUS	Arapahoe	250'		Yellowish-gray to yellowish-brown sandstone; siltstone and claystone; discontinuous conglomerate at base
UPPER CRETACEOUS	Laramie	700'		Gray, fine-to-medium-grained sandstone and silty clays; thin coal beds in lower part
UPPER CRETACEOUS	Fox Hills	60'		Tan, fine-to-medium-grained sandstone and sandy shale
UPPER CRETACEOUS	Pierre	± 8000'		Dark gray, silty shale and few thin, silty sandstones
UPPER CRETACEOUS	Niobrara	350'		Dark gray, very calcareous shale. "Foraminifers" abundant (Smoky Hills Member) Light gray, dense, fossiliferous limestone (Fort Hays Member)
UPPER CRETACEOUS	Benton	420'		Brown, sandy, fossiliferous limestone Dark gray shale with bentonite streaks; thin limestones in middle part; few cone-in-cone concretions in lower part Dark gray, brittle silty shale (Mowry)
LOWER CRETACEOUS	Dakota Group: So. Platte	270'		Light gray, fine-to-medium-grained sandstone, several dark gray shales in middle part
LOWER CRETACEOUS	Dakota Group: Lytle	100'		Light gray, fine-to-coarse-grained, locally conglomeratic sandstone; frequent red and green siltstone interbeds
Jurassic	Morrison	365'		Gray to greenish-gray to red shale and siltstone; thin limestones in middle part, lenticular sandstones in upper and lower part
Jurassic	Ralston Creek	110		Light tan siltstone and light red, silty shale, gypsiferous, sandstone at base and locally conglomeratic
TRI-ASSIC?	Lykins	400'		Red siltstone with two laminated limestones in lower part
PERMIAN	Lyons	120		Grayish-white, fine-to-medium-grained cross-bedded sandstone; conglomeratic lenses frequent
PENNSYLVANIAN	Fountain	1000'		Red, fine-to-coarse-grained sandstone and conglomerate; arkosic; thin, lenticular red siltstones frequent throughout
PRECAMBRIAN				Gneiss, schist, and small granitic intrusions

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Figure A-13

**Operable Unit No. 2
Generalized Stratigraphic Section
of the Denver Basin Bedrock**

Source: EG&G. 1991. " Draft Final Geologic Characterization Report for the RFP"

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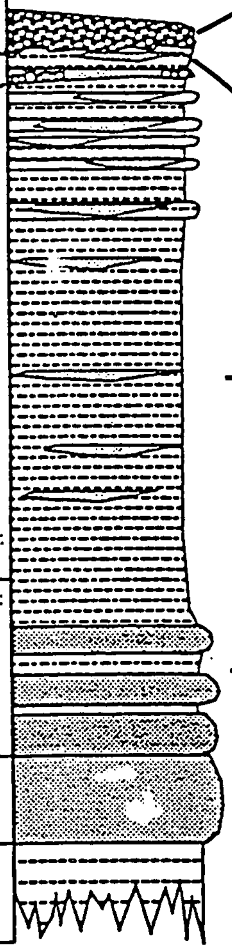
Age	Formation	Thickness (feet)
Quaternary	Rocky Flats Alluvium/ Colluvium	0-100
Cretaceous	Arapahoe Fm.	0-60
Cretaceous	Laramie Formation	600-800 upper interval: 300-500 lower interval: 300
Cretaceous	Fox Hills Sandstone	90-140
Cretaceous	Pierre Shale and older units	



Clayey Sandy Gravels - reddish brown to yellowish brown matrix, grayish-orange to dark gray, poorly sorted, angular to subrounded, cobbles, coarse gravels, coarse sands and gravelly clays; varying amounts of caliche

Claystones, Silty Claystones, and Sandstones - light to medium olive-gray with some dark olive-black claystone, silty claystone, and fine-grained sandstone, weathers yellowish orange to yellowish brown; a mappable, light to olive gray, medium- to coarse-grained, frosted sandstone to conglomeratic sandstone occurs locally at the base (Arapahoe marker bed)

Claystones, Silty Claystones, Clayey Sandstones, and Sandstones - kaolinitic, light to medium gray claystone and silty claystone and some dark gray to black carbonaceous claystone, thin (2') coal beds and thin discontinuous, very fine to medium-grained, moderately sorted sandstone intervals

Sandstones, Claystones, and Coals - light to medium gray, fine- to coarse-grained, moderately to well sorted, silty, immature quartzose sandstone with numerous claystones, and subbituminous coal beds and seams that range from 2' to 8' thick

Sandstones - grayish orange to light gray, calcareous, fine-grained, subrounded, glauconitic, friable sandstone

Source: EG&G. 1991. " Draft Final Geologic Characterization Report for the RFP"

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Figure A-14

Operable Unit No. 2
Generalized Stratigraphic Section of the Rocky Flats Environmental Technology Site

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Man-made deposits within the OU2 area have been identified using information from historical reports, air photography, and geologic field mapping. Three general categories of man-made deposits have been identified: soil and debris dumps, disturbed ground, and artificial fill.

Bedrock Geology

Bedrock geologic units within the OU2 area consist of claystones, siltstones, and sandstones. The No. 1 Sandstone is considered the basal part of the Arapahoe Formation. All lower bedrock units are considered to be a part of the upper Laramie Formation (DOE, 1993).

Subsurface investigations have shown that the Arapahoe Formation No. 1 Sandstone (No. 1 Sandstone) is a distinct bedrock unit separate in geologic characteristics from the underlying Laramie Formation. Most of the No. 1 Sandstones are predominantly fine- to medium-grained and represent deposition in low to moderate flow regimes. The No. 1 Sandstone is the stratigraphically highest sandstone encountered within the OU2 area. It is stratigraphically located from 0 to 20 feet below the overlying surficial deposits. The sandstone directly underlies the Rocky Flats Alluvium along a medial paleoscour beneath OU2. Prior to deposition of the Rocky Flats Alluvium, erosion of the claystone/siltsone material in this area created the paleoscour. The resulting subcrop area beneath the Rocky Flats Alluvium is an important feature in that it allows vertical groundwater flow to the No. 1 Sandstone from the overlying alluvial units.

The Laramie Formation is a fresh-to-brackish-water, non-marine deposit. Lithologic logging of the upper Laramie Formation suggests that in this area it is largely composed of claystone with lenses of fine-grained sandstone. The most common upper Laramie Formation lithologies encountered in boreholes within the OU2 area are claystones and silty claystones. The upper Laramie Formation sandstone or siltstone interbeds are approximately 10 feet thick, except where interbeds are stacked on top of each other. Where sandstone interbeds are stacked, a thicker sandstone sequence results. The sandstone interbeds are commonly separated by thin siltstone or claystone layers.

A.7 REGIONAL AND LOCAL HYDROGEOLOGY

This section describes the hydrogeology of the RFETS and specifically the OU2 study area, including the unconfined and confined ground water systems present at the RFETS. Unconfined ground water flow occurs in unconsolidated geologic materials (Rocky Flats alluvium, valley fill alluvium, and colluvium) and in subcropping bedrock (Arapahoe Formation) sandstones. Since unconfined flow occurs in more than one stratigraphic unit, the term "Upper Hydrostratigraphic Unit" (Upper HSU) is used to reference strata in which unconfined flow occurs. The Upper HSU also includes some saturated subcropping claystones that are weathered and fractured. Ground water flow in the lower (Laramie Formation) sandstone units, and in saturated zones of deeper (Laramie Formation) claystones with sufficient hydraulic conductivity, occurs under confined conditions. This deeper confined aquifer system is referred to as the

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"Lower Hydrostratigraphic Unit" (Lower HSU) to avoid confusion with the upper unconfined unit.

A.7.1 Regional Setting

The RFETS is situated in a regional ground water recharge area. Regionally, ground water flows from west to east in the Upper HSU and along the Arapahoe Formation-alluvium contact where the subcropping Arapahoe Formation consists of claystones, with local flow direction variations along drainages and bedrock topographic highs. Arapahoe Formation claystones have a low hydraulic conductivity (K), on the order of 10^{-7} cm/sec (approximately 0.1 feet per year (ft/yr)), effectively constraining much of the surficial recharge flow to the Upper HSU (see Parts II & III). Surficial recharge flow is further confined to the Upper HSU by the low K exhibited by upper Laramie Formation claystones which underlie the Arapahoe Formation sandstones of the Upper HSU.

The Upper HSU is characterized by rapid changes in water table elevation in response to short-term precipitation events. This is evident from the water level measurements taken from the ground water monitoring wells before and after precipitation events. Water levels in the Upper HSU are generally highest in spring and early summer and lowest during the winter months. In the western part of the RFETS, where the thickness of the surficial material is greatest, the depth to the water table (top of Upper HSU) is about 50 to 70 feet bgs. Although the water table depth is variable, it becomes shallower from west to east as the surficial material thins. Seeps are common in the stream drainages at the base of the Rocky Flats Alluvium, or where Arapahoe Formation sandstones are exposed.

The lower sandstone unit of the Laramie Formation and the underlying Fox Hills Sandstone comprise an important aquifer in the Denver Basin known as the Laramie/Fox Hills aquifer, referred to herein as the Lower HSU. The thickness of the aquifer near the center of the Denver Basin ranges from 200 to 300 feet. These formations outcrop west of the RFETS along the Front Range and dip between 45 and 50 degrees to the east. The dip of these formations decreases to less than 2 degrees beneath the central part of the RFETS. Ground water recharge to the Lower HSU occurs as precipitation and runoff infiltrates bedrock at the steeply dipping and eroded ends of the strata along the western limb of the monoclinal fold.

A.7.2 Operable Unit 2 Area Hydrogeology

Within OU2, the UHSU is comprised of variably and seasonally saturated parts of the unconsolidated surficial deposits, the No. 1 Sandstone that is in hydraulic connection with the saturated surficial materials, and weathered claystones of the Arapahoe and/or Laramie Formations. Laramie Formation sandstones that subcrop beneath the No. 1 Sandstone or saturated surficial soils also are considered part of the UHSU. The unconsolidated surficial deposits consist of the Rocky Flats Alluvium, colluvium, valley fill alluvium, and disturbed ground. Groundwater is present in the UHSU under unconfined conditions, except where parts of the No. 1 Sandstone are overlain by claystone, which results in both confined and unconfined

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conditions within the sandstone. Figure A-15 presents a schematic cross-section of the site hydrostratigraphy.

The UHSU is located over the relatively flat divide of South Walnut Creek and Woman Creek and is truncated to the north, east, and south along these drainages. The thickness and geometry of the UHSU geologic units are controlled by bedrock paleotopography, specifically the north and south paleoridges that generally trend east-northeast; the medial paleoscour that lies between the two paleoridges; other bedrock paleotopographic lows and steps that exist on the weathered bedrock paleotopographic surface; and depositional channels of the sandstones included in the UHSU. A bedrock paleotopographic map is provided in Figure A-16.

Groundwater flow within the UHSU is complex because of variations in groundwater flow directions, interactions between geologic units, and variations in degree of saturation and saturated thickness. Groundwater flow within the UHSU is strongly influenced by the bedrock paleotopography and the geometry and hydraulic characteristics of the unconsolidated deposits comprising the UHSU. Groundwater within the UHSU generally is found within the area described as the medial paleoscour (Figure A-16) and generally flows towards the northeast. In the area of Trench 2, immediately south of the drum storage site, groundwater locally flows to the south during high-water table conditions.

The areal extent and saturated thickness of the UHSU within the medial paleoscour vary seasonally. The north and south paleoridges restrict groundwater outflow from the alluvium to the north and south. The medial paleoscour is erosionally truncated along the north-facing hillslope of South Walnut Creek. UHSU groundwater discharges from the No. 1 Sandstone as seeps from this area.

Groundwater recharge to the UHSU within OU2 occurs as direct infiltration of precipitation, and by lateral and downward seepage from surface water features such as ditches. Recharge to the No. 1 Sandstone probably occurs from infiltration of precipitation and surface water through the overlying unsaturated surficial deposits, vertical groundwater flow from the overlying saturated surficial deposits, and inflow from the saturated sandstone units upgradient (west) of OU2.

A.8 ECOLOGY

The following sections describe vegetation, aquatic life, wildlife, threatened or endangered species, and sensitive environments at the RFETS and specifically OU2.

A.8.1 Rocky Flats Environmental Technology Site Ecology

A variety of plant life is found at the RFETS. The predominant vegetation found on the western portion of the site is disturbed mixed prairie, a mixture of both short- and mid-length grasses. The eastern portion of the RFETS is generally highly disturbed from overgrazing, and short grasses are dominant. Common grasses include smooth brome (*Bromus inermis*), crested

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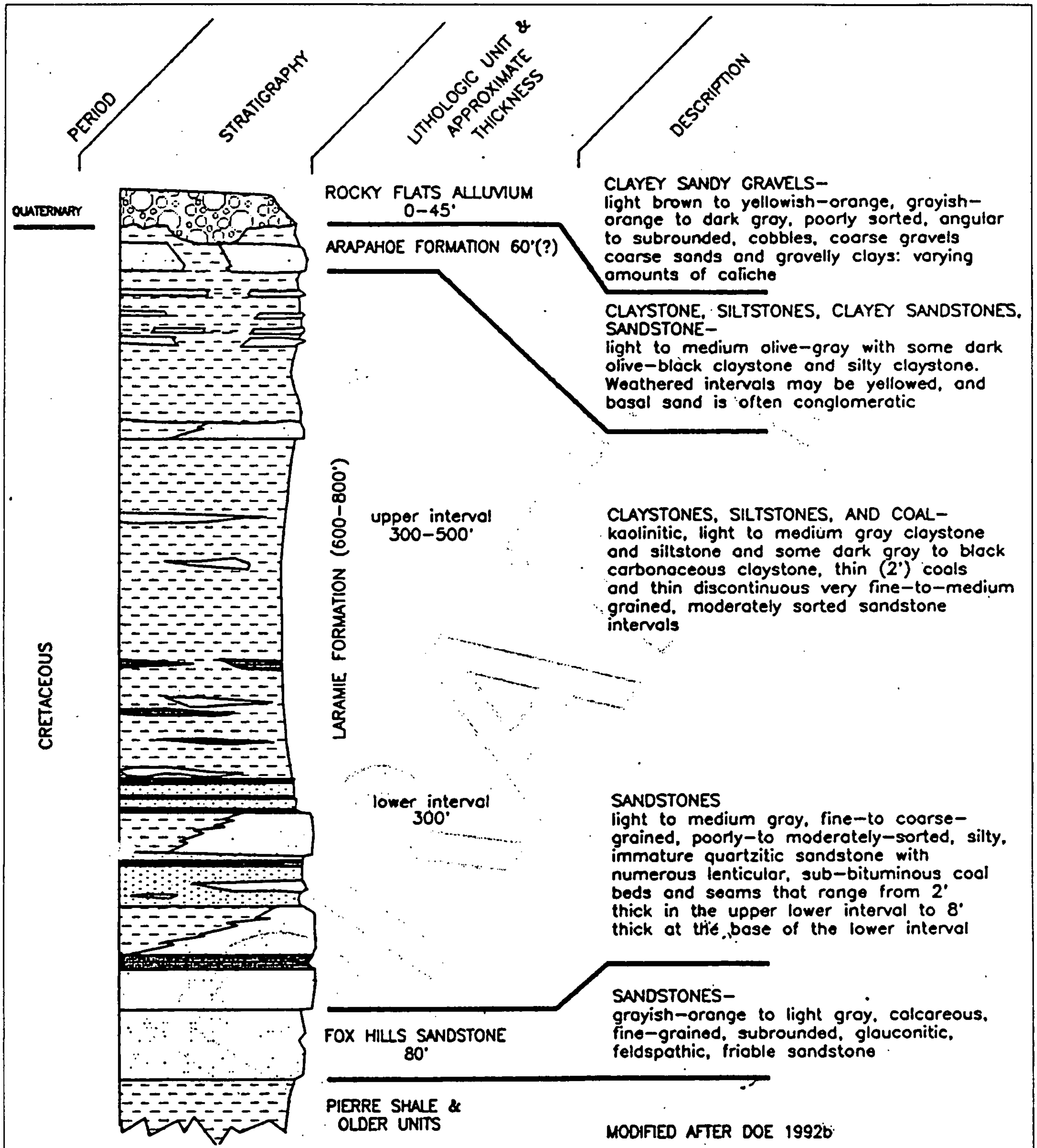

EXPLANATION

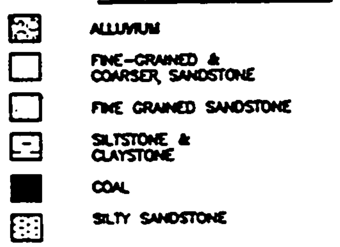

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Figure A-15

Operable Unit No. 2
Local Stratigraphic Column of
the ou-2 Area,
Rocky Flats Environmental Technology Site

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wheatgrass (*Agropyron cristatum)*, mountain muhly (*Muhlenbergia montana)*, and western wheatgrass (*Agropyron smithii*). Sedges (*Carex nebraskensis*) and rushes (*Juncus arcticus*) are found in stream floodplains and wet valley bottoms. Cottonwoods (*Populus sargentii*), baltic rush (*Juncus balticus)*, and cattails (*Typha latifolia*) line many riparian areas. Other species include salsify (*Tragopogon dubius*), kochia (*Kochia scoparia* and *iranica*), white sweet-clover (*Melilotus alba*), Canada thistle *(Cirsium arvense)*, and spike-rush. Since acquisition of the buffer zone property, vegetative recovery has occurred, as evidenced by the presence of disturbance-sensitive species such as big bluestem (*Andropogon gerardii*) and side oats grama (*Bouteloua curtipendula*). Figure A-17 illustrates the location of upland habitats at the RFETS.

Aquatic ecosystems present within the RFETS include perennial and intermittent streams, and human-made ditches, canals, ponds, and reservoirs. The principal components of the aquatic ecosystems are the periphyton, photoplankton, benthic macroinvertebrates, amphibians, and fish. The types of aquatic communities and diversity of species in each of these components are dependent on the type of substrate, water characteristics (such as depth and flow regime, water quality, and creek or pond morphology), water management practices, and season. Fish species are mostly absent in the intermittent streams, but are abundant in the larger ponds and reservoirs (DOE, 1992d).

Animal populations within the RFETS are representative of species typical of western prairie regions. A chain-link fence surrounding the industrial area effectively limits the habitat of the most common large mammal, the mule deer (*Odocoileus hemionus*), to the buffer zone. There are a number of small carnivores within the buffer zone, such as the coyote (*Canis latrans*), red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), long-tailed weasel (*Mustela frenata*), and the feral cat. Small herbivores are common throughout the RFETS complex and buffer zone, including the pocket gopher (*Thomomys sp.*), white-tailed jackrabbit (*Lepus townsendii*), deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), and meadow vole (*Microtus pennsylvanicus*) (DOE, 1980).

Commonly observed birds include the horned lark (*Eremophila alpestris*), western meadowlark (*Sturnella neglecta*), mourning dove (*Zenaidura macroura*), vesper sparrow (*Pooecetes gramineus*), western kingbird (*Tyrannus verticalis*), black-billed magpie (*Pica pica*), American robin (*Turdus migratorius*), English sparrow (*Passer domesticus*), house finch (*Carpodacus mexicanus*), Say's phoebe (*Sayornis saya*), barn swallow (*Hirundo rustica*), starling (*Sturnus vulgaris*), and yellow warbler (*Dendroica petechia*). Mallards (*Anas platyrhynchos*) and other ducks (*Anas spp.*) often nested on several of the SEPs when they were in operation. Killdeer (*Charadrius vociferus*) and red-winged blackbird (*Agelaius phoeniceus*) are found in areas adjacent to the SEPs. Birds of prey commonly seen in the area include the marsh hawk (*Circus cyaneus*), red-tailed hawk (*Buteo jamaicensis*), ferruginous hawk (*Buteo regalis*), rough-legged hawk (*Buteo lagopus*), American kestrel (*Falco sparverius*), swainson's hawk (Buteo-swainsoni) and the great horned owl (*Bubo virginianus*) (DOE, 1980).

Rattlesnakes (*Crotalus viridis*) and bullsnakes (*Pituophis melanoleucus*) are the most frequently observed reptiles. Eastern yellow-bellied racers (*Coluber constrictor falviventris*)

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have also been observed. The eastern short-horned lizard (*Phrynosoma douglassi*) has been reported on the site, but these and other lizards are not commonly seen. The western painted turtle (*Chrysemys picta*) and the western plains garter snake (*Thamnophis radix*) are found in and around many of the ponds on the RFETS property (DOE, 1980).

Rocky Flats Environmental Technology Site Threatened or Endangered Species

Threatened or endangered plant and animal species that could potentially occur at the RFETS have been identified. Plant species identified as threatened, endangered, or special-species status are the forktip threeawn (*Aristida basiramea*), Colorado butterfly plant (*Gaura neomexicana*), Toothcup (*Rotala ramosior*), and Diluvium Lady's Tresses (*Spiranthes diluvialis*). None of the vegetative species present at the RFETS is reported to be on the threatened or endangered species list (DOE, 1991a). Only the forktip threeawn (special status plant) has been observed at the RFETS (EG&G, 1992c). Threatened or endangered wildlife species that could potentially occur at the RFETS include the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), whooping crane (*Grus americana*), the preebles meadow jumping mouse (*Zapus hudsonium prebleii*) and blackfooted ferret (*Mustela nigripes*). Bald eagles have been observed soaring over the RFETS developed area and flying over the northeastern portion of the buffer zone. Two peregrine falcons were observed at the RFETS in early fall of 1991, and noted in the "Final Habitat Survey Report." (EG&G, 1992c). The preebles meadow jumping mouse has been identified to inhabit the area along the banks of North Walnut Creek. Ongoing OU investigations are providing site-specific biological data for plant and animal communities. Refer to the following documents for a complete listing of plant and animal species observed or with the potential to occur at the RFETS:

U.S. Department of Energy (DOE) 1980
Final Environmental Impact Statement

U.S. Department of Energy (DOE) 1991
Baseline Wildlife/Vegetation Studies Status Report
Rocky Flats Plant, Golden, CO

U.S. Department of Energy (DOE) 1991
Final Habitat Survey Report Fish and
Wildlife Coordination Act Migratory Bird
Treaty Act Compliance. 881 Hillside French
Drain (881-HFD) Project.
Rocky Flats Plant, Golden, CO

EG&G 1991
Threatened and Endangered Species Evaluation
Rocky Flats Plant, April, 1991

EG&G 1992
Environmental Restoration Technical Support
Document: A NEPA Support Document for Rocky Flats Plant

<u>Rocky Flats Environmental Technology Site Sensitive Environments (Riparian and Wetland Areas)</u>

The U.S. Army Corps of Engineers (USACE) defines wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (U.S. Department of Defense, 1987 *Corps of Engineers Wetlands Delineation Manual*). Wetland assessments have identified a variety of wetland areas at the RFETS including intermittent streams, hillside seeps, several ponds, and an open lake. Many of the RFETS wetlands were classified based on the U.S. Fish and Wildlife Service wetlands classification system. Palustrine, and to a much lesser extent, riverine and lacustrine, wetland types were identified and mapped for the RFETS (ASI, 1990). There are approximately 107 acres of aerial wetlands and 84,970 feet of linear wetlands within the boundaries of the RFETS. Wetland vegetation includes cattails, willows, cottonwoods, and some grasses and forbs (EG&G 1992f).

A.9 SOCIAL AND ECONOMIC RESOURCES

The following 4 subparts to A.9 detail the site's potential for future use based on cultural response surveys, visual resources, recreational possibilities, and public road access.

A.9.1 Site, Local Cultural, and Archeological Resources

Two large-scale and at least two small-scale cultural resource surveys have been completed for 5,900 acres of the RFETS (EG&G, 1992c). Areas excluded from survey were the inner RFETS zone now known as the Protected Area and all designated solid waste management units. These surveys recorded 37 cultural resource sites and 26 isolated finds. Thirty-five sites were dated from the 1870s through the mid-1900s, and were associated with agriculture and ranching. Ditches, stock watering ponds, building remains, a trash dump, rock piles, corrals and an orchard are examples of historic sites (EG&G, 1992c). Two Native American occupation sites were also recorded. These sites consisted of low circular rock piles and a series of linear stone alignments. No artifacts were associated with either of these sites. The 35 historic sites do not qualify for eligibility on the National Register of Historic Places, and no eligibility recommendations have been made for the two Native American sites (EG&G, 1992c).

A.9.2 Visual Resources

The region around the RFETS offers a variety of scenic experiences to users of the area due to the diversity of the topography and geologic formations characteristic of Colorado's Front Range. The RFETS location also provides a scenic view of the Denver metropolitan area. The RFETS and the OU2 area are not considered to have the scenic attributes of the surrounding natural region. The RFETS does not contain distinctive landscape features to distinguish it from adjacent landscapes. The landscape scenic quality for the RFETS is "common" in classification (EG&G, 1992c).

Colorado State Highways 72, 93, and 128, along with Jefferson County Highway 17, provide the primary views from travel routes. These highways, as well as being the principal transportation routes, are also the dominant human-made features surrounding the RFETS. The numerous structures on the RFETS property constitute the other highly noticeable human-made features in the area.

A.9.3 Recreation

There are several recreational areas in the general vicinity of the RFETS including Standley Lake Park, Boulder Mountain Park, Jefferson and Boulder Counties open spaces, and other public lands. Much of the recreational activity involves hiking, climbing, biking, and other opportunities common to large expanses of public land. Hunting and fishing are not allowed in any areas around the RFETS. No recreational activities are allowed within the RFETS boundaries, and public access to the facility is restricted.

A.9.4 Transportation

The primary transportation routes through the region are Colorado State Highways 72, 93, 128, and Jefferson County Highway 17. Numerous county and other roads exist in the residential and commercial areas to the north, east, and south of the RFETS. The heaviest traffic volume is on weekdays during the morning and evening rush hours. The 20-year traffic projection for the area north and south of the intersection of State Highways 72 and 93 is 22,000 average daily traffic (ADT), and 20,000 ADT, respectively (DRCOG, 1994).

Access to the RFETS property is attained by turning west from Indiana Avenue onto the East Access Road, or by turning east from Colorado Highway 93 onto the West Access Road (EG&G, 1992c).

Central Avenue (paved) runs along the northern extent of OU2. A dirt road runs along the southern extent of OU2.

APPENDIX B

REMEDIATION GOAL AND CONTAMINATED SOIL VOLUME CALCULATIONS

PURPOSE: CALCULATE THE VOLUME OF SURFACE SOIL REQUIRED TO BE EXCAVATED FOR VARIOUS ANALYSES IN THE ANALYSIS OF ALTERNATIVES.

BASIS: SURFACE SOIL SAMPLING WAS CONDUCTED DURING THE RFI/RI AT 2.5 AND 10 ACRE PLOTS. HUMAN HEALTH RISK FROM SURFICIAL CONTAMINATION WAS ESTABLISHED IN THE BRA. THE VOLUME ESTIMATES ARE BASED ON THE RFI/RI RESULTS, BRA RESULTS, AND BRA RISK ASSESSMENT METHODOLOGIES. SEE ATTACHED SHEET FOR EXCAVATED AREA DETERMINATIONS

ASSUMPTIONS AND CONSIDERATIONS: THE MAJORITY OF SURFICIAL CONTAMINATION IS CONFINED TO THE UPPER 15 CM OF SOIL OUTSIDE THE 903 PAD AND LIP AREA. THE 903 PAD WAS COVERERED WITH 20 CM OF CLEAN FILL THAT HAS BEEN SUBSEQUENTLY CONTAMINATED. THE 20 CM OF NATURAL SOIL BENEATH THE FILL CONTAINS THE MAJORITY OF THE CONTAMINATION BOTH BENEATH THE PAD AND LIP AREA. THEREFORE, THE FOLLOWING DEPTHS TO BE EXCAVATED, AS REQUIRED, ARE:

903 PAD: ASPHALT PLUS 40 CM BENEATH ASPHALT
903 LIP AREA: 20 CM
OTHER AREAS: 15 CM (15 CM

THESE VALUES WILL BE USED TO DETERMINE COMPARATIVE VOLUMES FOR THE THREE CASES. BECAUSE THIS IS A COMPARATIVE ANALYSIS AND BECAUSE EXACT VOLUME ESTIMATES CANNOT BE DETERMINED, ESTIMATES FOR THE AREAL EXTENT OF CONTAMINATION ARE USED.

FOR EACH OF THE CASES, THE 903 PAD AND LIP AREA WILL BE EXCAVATED TO PREVENT EROSION OF THE SOILS VIA WIND AND SURFACE WATER.

THE AREAS TO BE EXCAVATED COULD INCLUDE:

- THE 903 PAD - IHSS 112
- THE 903 PAD LIP AREA - IHSS 183, AND INCLUDES THE SURFACE SOILS FROM TRENCH T-2, T903A, REACTIVE METAL DESTRUCTION SITE.
- SURFACE SOIL PLOTS 29, 34, 35 AND 46 NOT INCLUDED ABOVE
- PLOT 46

CALCULATE VOLUMES

903 PAD: THE PAD CONSISTS OF AN ASPHALTIC LAYER ABOVE APPROX. 20 CM OF FILL OVER APPROX 20 CM OF CONTAMINATED SOIL. ASSUME A 3-INCH ASPHALTIC LAYER. ∴ THE VOLUME TO BE EXCAVATED IS:

ASPHALT LAYER + 20 cm FILL + 20 CM SOIL

$$\text{ASPHALT LAYER VOLUME} = (3\,in)\left(\frac{1\,ft}{12\,in}\right)(3.4\,acre)\left(\frac{43560\,ft^2}{acre}\right)$$
$$= 37{,}026\,ft^3 = \boxed{1370\,yd^3}$$

$$\text{FILL VOLUME or SOIL VOLUME} = (20\,cm)\left(\frac{1\,in}{2.54\,cm}\right)\left(\frac{1\,ft}{12\,in}\right)(3.4\,acre)\left(\frac{43560\,ft^2}{acre}\right)$$
$$= 97{,}181\,ft^3 = \boxed{3600\,yd^3}$$

Total Volume = (Volume of Pad) + (Volume of fill) + (Volume of Contaminated Soil)

$$\text{TOTAL VOLUME} = 1370 + 3600 + 3600 = \boxed{8570\,yd^3}$$

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PARSONS ENGINEERING SCIENCE, INC.

Client RMRS	Job No. 726118	Sheet 1 of 1
Subject OU2 IM/IRA - CONTAMINATED SURFACE SOIL VOLUME ESTIMATES	By EF Krohn, Jr.	Date 23 AUG 95
	Checked SR HUGHES	Rev. 2

PURPOSE: RECALCULATE VOLUMES PER CHANGES IN DOSE EQUIVALENTS

EXCAVATION DEPTHS: 903 PAD 40CM
903 LIP 20 CM
BUFFER ZONE 15CM

NEW DATA (pCi/g):

	15 mrem		100 mrem	
	Pu 239	Am 241	Pu 239	Am 241
OFFICE WORKER	1,600	140	11,000	940
OPEN SPACE	16000	1400	110000	3600

ATTACHMENTS 1 AND 2 DISPLAY THE AREAL EXTENT OF SOILS TO BE REMOVED. NO Pu-239 EXCEEDENCES WERE IDENTIFIED. Approximately 3.1 Acres of office worker soils exceeded 15 mrem Am-241 levels. No exceedences were IDENTIFIED FOR 100 mrem Am-241 dose

Total Volume of Soil To Be Removed from 903 PAD (Cubic YARDS) =

$$(3.1\,\text{Acres})\left(\frac{43560\,ft^2}{\text{Acre}}\right)(20\,cm)\left(\frac{1\,in}{2.54\,cm}\right)\left(\frac{1\,ft}{12\,in}\right)\left(\frac{1\,Cy}{27\,ft^3}\right) = \underline{\underline{3280\,Cy}}$$

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APPENDIX C

ALTERNATIVE COST ESTIMATES

OU 2 PHASE II CMS/FS - ALTERNATIVES COST ANALYSIS

ROUGH ORDER OF MAGNITUDE (ROM) ESTIMATE

ASSUMPTIONS

General

- Rough-Order-of-Magnitude estimates were conducted for each alternative. The level of detail was limited to this type of estimate.
- Areas and volumes requiring remediaton are based on the calculations performed on August 23, 1995 by E.F. Krohn, Jr and from the Final Screening of Process Options and Detailed Descriptions of Media-Specific Alternatives for Operable Unit No. 2 report. A summary of these values is as follows:
  - Hillside soils: Area = 3.1 acres. Volume for a 20 cm excavation = 3280 CY.
  - 903 Pad: Area =3.4 acres. Volume of 3-inch thick asphalt layer = 1370 CY. Volume for a 40 cm excavation = 7200 CY.
- Equipment used for the estimate was based on locally available equipment. Equipment was limited by the size of the site and of the staging and laydown areas.
- Delivery Operations: Delivery rates were estimated on a maximum frequency of one truck for every 15 minutes due to security checks of the trucks..
- Onsite Hauling Operations: Onsite hauling and handling costs included costs for one off-road truck, one front end loader, and a water truck.
- Compaction: Costs for compacted lifts are adjusted for a 6-inch lift. Therefore, the areas were adjusted to reflect the number of required lifts for each soil layer.
- Productivity Factors: Established productivity factors for RFETS have not been incorporated into the estimate.
- Building Factors were not incorporated into these estimates.
- Erosion control of the surrounding site was not considered.
- In determining the present value of each alternative, the life of the alternative was 30 years, while the interest rate was 3.5 percent. A

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uniform gradient increase was applied to the maintenance cost of approximately 3.5 percent to account for escalation of maintenance costs over the 30 year life of the alternative.

No Further Action

- Costs were limited to yearly maintenance costs.

Institutional Controls

- No cost analysis was conducted for this alternative.

Enhanced Vegetative Cover

- Estimated duration for the entire construction project is 20 weeks.
- Cover materials will be delivered one week prior to construction activities in the laydown area. Stockpiled materials will allow construction to proceed without delays. Stockpiled materials shall be properly segregated.
- Layers for the enhanced vegetative cover consist of the following:
  - 6.5-inches of excavated 903 Lip Area soils.
  - 18-inches of 6-inch to 10-inch angular riprap.
  - 6-inches of 2-inch to 4-inch angular gravel.
  - Geotextile Fabric.
  - 12-inches of clean soil backfill.
  - 12-inches of topsoil/gravel admixture.
  - 2-inches of pea gravel.
  - surface vegetative cover.
- 903 Lip Area soils will be excavated and transported to the 903 Pad for placement.

Onsite Disposal

- Estimated duration for the entire construction project is 13 weeks.
- Onsite disposal shall consist of the following activities:

- Excavation of the contaminated soils.
- Transport of the contaminated soils.
- Storage of the contaminated soils.
- Monitoring of contaminated soils.
- Transport of contaminated soils.
- Disposal of contaminated soils. (Tipping fee of $250/CY).

- Erosion Control Protection is required prior to construction due to the delayed availability of the onsite disposal facility. Onsite disposal could not occur prior to the construction of the onsite CAMU. Costs for erosion control were not calculated.

<u>*Ex Situ* Stabilization</u>

- Estimated duration for the entire construction project is 22 weeks.
- Wastech, Inc. provided estimated costs to stabilize the soils. Wastech has demonstrated the ability to stabilize contaminated soils under many conditions, including DOE sites.
- The 903 Pad asphalt layer will be size-reduced into fractions less than 3-inches in diameter prior to stabilization.
- Course-grained soil particles greater than 1-inch in diameter shall be separated and returned to the excavation prior to stabilization. Dry separation techniques were incorporated. It was estimated that 20 percent (by volume) of the soil would be > 1-inches.
- It was estimated that the volume increase following stabilization would be 20 percent.
- Stabilized soils were returned to the original excavation.
- 24-inches of subsoil (topsoil/gravel admixture) shall be placed on the stabilized soils. 6-inches of topsoil shall be placed on top of the subsoil to support vegetative growth.

OU 2 PHASE II CMS/FS - ALTERNATIVES COST ANALYSIS

ROUGH-ORDER-OF-MAGNITUDE (ROM) ESTIMATE

NO FURTHER ACTION

Task No.	Task Description	Quantity	Units	Labor		Materials		Equipment		Subcontract		Total
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Amount
	INDIRECT COSTS											
	NONE REQUIRED											0
	DIRECT FIELD COSTS											
	NONE REQUIRED											0

TOTAL CAPITAL COST 0

Task No.	Task Description	Quantity	Units	Labor		Materials		Equipment		Subcontract		Total
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Amount
	YEARLY MAINTENANCE COSTS											
	SAMPLING AND ANALYSIS	40	EACH	120	4,800			40	1,600	1,000	40,000	46,400
	RAD SURVEY	4	EACH	4800	19,200							19,200
	SITE INSPECTION	24	EACH	320	7,680							7,680

TOTAL YEARLY MAINTENANCE COST 73,280

PRESENT VALUE CALCULATION

General Information:

Capital cost = 0.
Yearly Maintenance Cost = - $73,280
Life of Alternative (n) = 30 years
Annual Inflation Rate (i) = 3.5 percent
Uniform Gradient Increase in Maintenance = $2,600

Present Value of Yearly Maintenance

(P/A, i, n) + (P/G, i, n)
P = A(P/A,i%,n) + G(P/G,i%,n)
= -$73,280(18.3920) - $2,600(220.1055)
= - $1,920,040

TOTAL PRESENT VALUE 1,920,000

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OU 2 PHASE II CMS/FS - ALTERNATIVES COST ANALYSIS

ROUGH-ORDER-OF-MAGNITUDE (ROM) ESTIMATE

ENHANCED VEGETATIVE COVER

Task No.	Task Description	Quantity	Units	Labor Unit Price	Labor Amount	Materials Unit Price	Materials Amount	Equipment Unit Price	Equipment Amount	Subcontract Unit Price	Subcontract Amount	Total Amount
	INDIRECT COSTS											
	DEED RESTRICTIONS	1	EACH							50,000	50,000	50,000
	TRAINING	600	MH	[illegible]	24,000							24,000
	SET-UP STAGING AREA	40	MH	65	2,600							2,600
	SET-UP EXCLUSION ZONES	40	MH	65	2,600							2,600
	SET-UP LAYDOWN AREA	1	LS								10,000	10,000
	DECON WASH AREA	20	DAYS	200	4,000				10,000			14,000
	SANITARY	5	MONTHS					560	2,800			2,800
	HEALTH AND SAFETY SUPPLIES	1	LS								20,000	20,000
	MOBILIZATION	120	MH	40	4,800		5,000					9,800
	MOBILE GEOTECH LAB	3	MONTHS							700	2,100	2,100
	GEOTECH TECHNICIAN	540	MH	80	43,200							43,200
	RAD TECHNICIANS	160	MH	120	19,200							19,200
	QUALITY ASSURANCE	100	MH	65	6,500							6,500
	AIR MONITORING	1	LS								25,000	25,000
	FINAL SITE SURVEY	1	LS								2,000	2,000
	DEMOB/SITE CLEAN-UP	320	MH	40	12,800							12,800
	Subtotal of Indirect Costs											246,600
	DIRECT FIELD COSTS											
	VEGETATION REMOVAL											
	VEGETATION REMOVAL	2500	CY	2.00	5,000			1.50	3,750			8,750
	SURFACE PREPARATION	15,000	SY	0.05	750			0.15	2,250			3,000
	MOVE HILLSIDE SOILS											
	EXCAVATE SOILS	3280	CY	1.50	4,920			1.00	3,280			8,200
	TRANSPORT SOILS	3280	CY	2.00	6,560			1.50	4,920			11,480

GRADE SOILS	15,000	SY	0.05	750			0.15	2,250			3,000
COMPACT SOILS	19,600	SY	1.00	19,600			0.50	9,800			29,400
DELIVERY OF BACKFILL	3,600	CY			6.27	22,572					22,572
GRADE BACKFILL	15,000	SY	1.00	15,000			0.50	7,500			22,500
INSTALL VEG. COVER											
DELIVERY OF RIPRAP	9700	CY			18.28	177,316					177,316
GRADE RIPRAP	60,000	SY	0.05	3,000			0.15	9,000			12,000
DELIVERY OF GRAVEL	3250	CY			15.07	48,978					48,978
GRADE GRAVEL	19,360	SY	0.05	968			0.15	2,904			3,872
DELIVERY OF GEOTEXTILE	19,360	SY			1.80	34,848					34,848
PLACEMENT OF GEOTEXTILE	19,360	SY	0.75	14,520			0.45	8,712			23,232
DELIVERY OF BACKFILL	6500	CY			6.27	40,755					40,755
GRADE BACKFILL	40,000	SY	0.05	2,000			0.15	6,000			8,000
COMPACT BACKFILL	19,360	SY	1.00	19,360			0.50	9,680			29,040
DELIVERY OF TOPSOIL/GRAVEL	6500	CY			19.03	123,695					123,695
GRADE TOPSOIL/GRAVEL	40,000	SY	1.00	40,000			0.50	20,000			60,000
DELIVERY OF PEA GRAVEL	1100	CY			15.5	17,050					17,050
GRADE PEA GRAVEL	19,360	SY	0.05	968			0.15				968
INSTALL PERIMETER FENCING	3400	LF	8.50	28,900	5.70	19,380					48,280
SEEDING											
ENGINEERED COVER AREA	4	ACRES					2,500	10,000			10,000
EXCAVATED HILLSIDE	4	ACRES					2,500	10,000			10,000
Subtotal of Direct Costs											756,936
OVERHEAD AND PROFIT											
CONTRACTOR OVERHEAD (15 %)											143,030
CONTRACTOR PROFIT (8%)											76,283

TOTAL CAPITAL COST 1,222,849

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Task No.	Task Description	Quantity	Units	Labor Unit Price	Labor Amount	Materials Unit Price	Materials Amount	Equipment Unit Price	Equipment Amount	Subcontract Unit Price	Subcontract Amount	Total Amount
	YEARLY MAINTENANCE COSTS											
	SAMPLING AND ANALYSIS	40	EACH	120	4,800			40	1,600	1,000	40,000	46,400
	RAD SURVEY	4	EACH	4800	19,200							19,200
	SITE INSPECTION	24	EACH	320	7,680							7,680
	SITE MOWING OPERATIONS	1	EACH	320	320			160	160			480
	SITE REPAIRS	1	EACH	640	640			400	400		9,000	10,040

TOTAL YEARLY MAINTENANCE COST 83,800

PRESENT VALUE CALCULATION

General Information;
Capital Cost = - $1,222,849
Yearly Maintenance Cost = - $83,800
Life of Alternative (n) = 30 years
Annual Inflation Rate (i) = 3.5 percent
Uniform Gradient Increase in Maintenance = $2,900

Present Value of Yearly Maintenance
(P/A, i, n) + (P/G, i, n)
P = A(P/A,i%,n) + G(P/G,i%,n)
= - $83,800(18.3920) - $2,900(220.1055)
= - $2,179,556

TOTAL PRESENT VALUE 3,402,400

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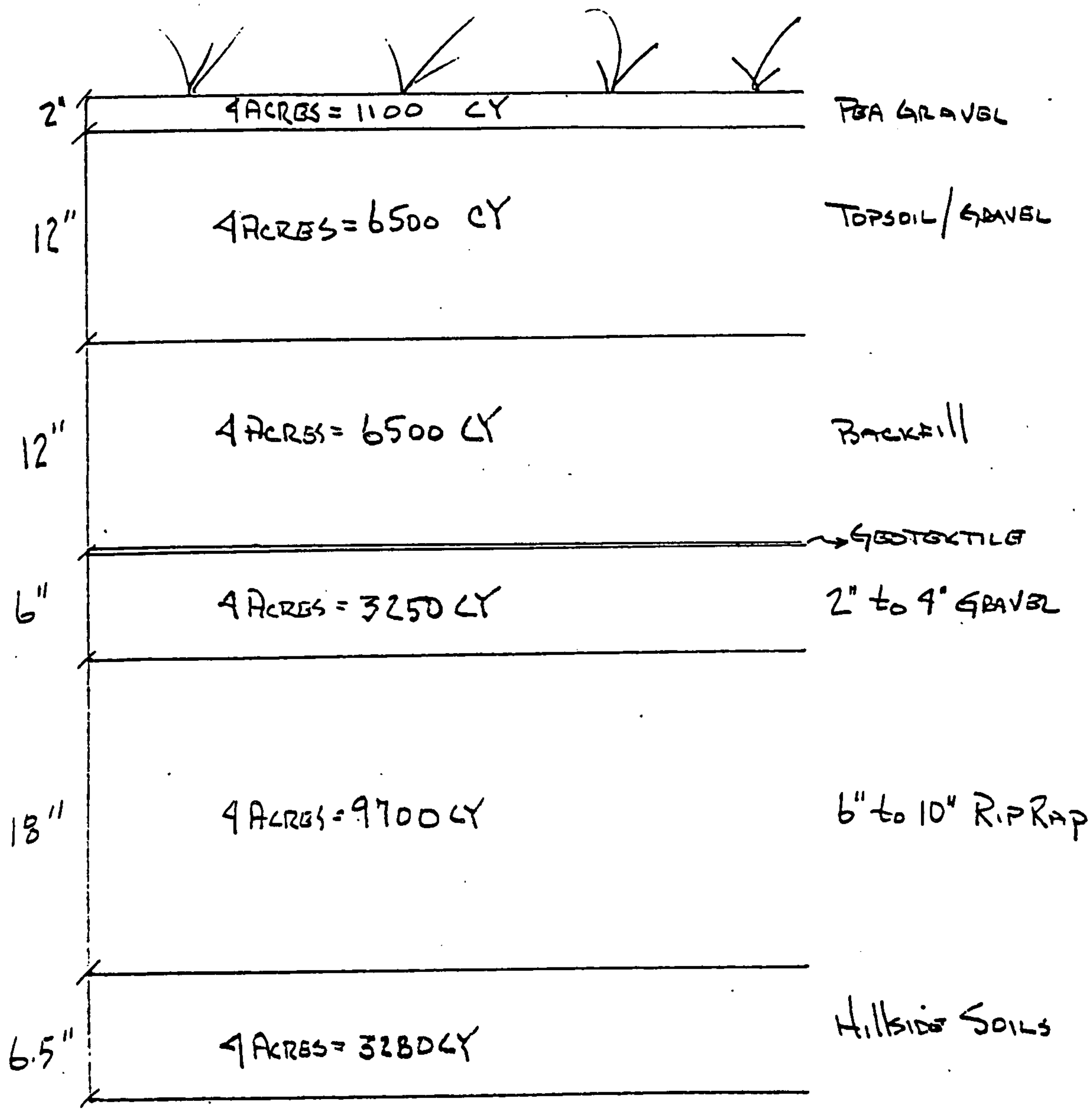
VEGETATING COVER



OU 2 PHASE II CMS/FS - ALTERNATIVES COST ANALYSIS

ROUGH-ORDER-OF-MAGNITUDE (ROM) ESTIMATE

EXCAVATION AND ONSITE DISPOSAL

Task No.	Task Description	Quantity	Units	Labor Unit Price	Labor Amount	Materials Unit Price	Materials Amount	Equipment Unit Price	Equipment Amount	Subcontract Unit Price	Subcontract Amount	Total Amount
	INDIRECT COSTS											
	DEED RESTRICTIONS	1	EACH							50,000	50,000	50,000
	TRAINING	600	MH	40	24,000							24,000
	SET-UP STAGING AREA	40	MH	65	2,600							2,600
	SET-UP EXCLUSION ZONES	40	MH	65	2,600							2,600
	SET-UP LAYDOWN AREA	1	LS								10,000	10,000
	DECON WASH AREA	20	DAYS	200	4,000				10,000			14,000
	SANITARY	3	MONTHS					560	1,680			1,680
	HEALTH AND SAFETY SUPPLIES	1	LS								15,000	15,000
	MOBILIZATION	120	MH	40	4,800		5,000					9,800
	RAD TECHNICIANS	120	MH	120	14,400							14,400
	QUALITY ASSURANCE	100	MH	65	6,500							6,500
	AIR MONITORING	1	LS								30,000	30,000
	ONSITE TIPPING FEE	11,850	CY							250	2,962,500	2,962,500
	FINAL SITE SURVEY	1	LS								2,000	2,000
	DEMOB/SITE CLEAN-UP	320	MH	65	20,800							20,800
	Subtotal of Indirect Costs											3,165,880
	DIRECT FIELD COSTS											
	REMOVE HILLSIDE SOILS											
	ACCEPTANCE CRITERIA SAMPLING	13	DAYS									0
	EXCAVATE SOILS	3280	CY	1.50	4,920			1.00	3,280			8,200

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TRANSPORT SOILS	3280	CY	2.00	6,560			1.50	4,920			11,480
MATERIAL HANDLING FOR TRANSPORT	3280	CY							16	52,480	52,480
DELIVERY OF BACKFILL	3,600	CY			6.27	22,572					22,572
GRADE BACKFILL	15,000	SY	0.05	750			0.15	2,250			3,000
REMOVE 903 PAD AND SOILS											
EXCAVATE ASPHALT/SOILS	8570	CY	1.50	12,855			1.00	8,570			21,425
TRANSPORT ASPHALT/SOILS	8570	CY	2.00	17,140			1.50	12,855			29,995
MATERIAL HANDLING FOR TRANSPORT	8570	CY							16	137,120	137,120
DELIVERY OF BACKFILL	9,500	CY			6.27	59,565					59,565
GRADE BACKFILL	50,000	SY	0.05	2,500			0.15	7,500			10,000
SEEDING											
903 PAD AREA	4	ACRES					2,500	10,000			10,000
EXCAVATED HILLSIDE	4	ACRES					2,500	10,000			10,000
Subtotal of Direct Costs											375,837
OVERHEAD AND PROFIT											
CONTRACTOR OVERHEAD (12 %)											63,506
CONTRACTOR PROFIT (8 %)											42,337

TOTAL CAPITAL COST 3,647,560

Task No.	Task Description	Quantity	Units	Labor		Materials		Equipment		Subcontract			Total Amount
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount		
	YEARLY												
	MAINTENANCE COSTS												
	NONE EXPECTED												

TOTAL YEARLY MAINTENANCE COST | 0 |

PRESENT VALUE CALCULATION

General Information:
Capital Cost = - $3,647,560
Yearly Maintenance Cost = 0
Life of Alternative (n) = Indefinite
Annual Inflation Rate (i) = N/A

Present Value of Yearly Maintenance
N/A

TOTAL PRESENT VALUE | $3,647,560 |

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OU 2 PHASE II CMS/FS - ALTERNATIVES COST ANALYSIS

ROUGH-ORDER-OF-MAGNITUDE (ROM) ESTIMATE

***EX SITU* STABILIZATION**

Task No.	Task Description	Quantity	Units	Labor		Materials		Equipment		Subcontract		Total Amount
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	
	INDIRECT COSTS											
	DEED RESTRICTIONS	1	EACH							50,000	50,000	50,000
	TRAINING	600	MH	40	24,000							24,000
	SET-UP STAGING AREA	40	MH	65	2,600							2,600
	SET-UP EXCLUSION ZONES	40	MH	65	2,600							2,600
	SET-UP LAYDOWN AREA	1	LS								10,000	10,000
	DECON WASH AREA	20	DAYS	200	4,000				10,000			14,000
	SANITARY	6	MONTHS					560	3,360			3,360
	HEALTH AND SAFETY SUPPLIES	1	LS								25,000	25,000
	MOBILIZATION	240	MH	40	9,600		5,000					14,600
	RAD TECHNICIANS	240	MH	120	28,800							28,800
	QUALITY ASSURANCE	200	MH	65	13,000							13,000
	FINAL SITE SURVEY											
	DEMOB/SITE CLEAN-UP	400	MH	65	26,000							26,000
	Subtotal of Indirect Costs											213,960
	DIRECT FIELD COSTS											
	STABILIZE HILLSIDE SOILS											
	EXCAVATE SOILS	3280	CY	1.50	4,920			1.00	3,280			8,200
	SOIL SEPARATION (<1-INCH)	3280	CY	1.51	4,953			1.01	3,313			8,266
	TRANSPORT SOILS > 1-INCH	660	CY	2.00	1,320			1.50	990			2,310
	BACKFILL SOILS > 1-INCH	660	CY	0.05	33			0.15	99			132

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STABILIZE SOILS	2620	CY							300	786,000		786,000
TRANSPORT SOILS	3150	CY	2.00	6,300			1.50	4,725				11,025
BACKFILL SOILS	3150	CY	0.05	158			0.15	473				630
FINAL SITE GRADING	15,000	SY	0.05	750			0.15	2,250				3,000
STABILIZE 903 PAD ASPHALT												
EXCAVATE ASPHALT	1370	CY	2.50	3,425			0.84	1,151				4,576
GRIND ASPHALT	16500	SY	0.24	3,960				10,000				13,960
STABILIZE ASPHALT	1370	CY							300	411,000		411,000
TRANSPORT ASPHALT	1650	CY	2.00	3,300			1.50	2,475				5,775
BACKFILL ASPHALT	1650	CY	0.05	83			0.15	248				330
STABILIZE 903 PAD SOILS												
EXCAVATE SOILS	7200	CY	1.26	9,072			0.84	6,048				15,120
SOIL SEPARATION (<1-INCH)	7200	CY	1.51	10,872			1.01	7,272				18,144
TRANSPORT SOILS > 1-INCH	1440	CY	2.00	2,880			1.50	2,160				5,040
BACKFILL SOILS > 1-INCH	1440	CY	0.06	86			0.04	58				144
STABILIZE SOILS	5760	CY							300	1,728,000		1,728,000
TRANSPORT SOILS	6910	CY	2.00	13,820			1.50	10,365				24,185
BACKFILL SOILS	6910	CY	0.05	346			0.15	1,037				1,382
VEGETATIVE COVER												
DELIVERY OF SUBSOIL	21,100	CY			6.27	132,297						132,297
GRADE SUBSOIL	31,500	SY	0.05	1,575			0.15	4,725				6,300
DELIVERY OF TOPSOIL	5,300	CY			19.03	100,859						100,859
GRADE TOPSOIL	31,500	SY	0.05	1,575			0.15	4,725				6,300
FINAL SITE GRADING	31,500	SY	0.05	1,575			0.15	4,725				6,300
SEEDING												
903 PAD AREA	4	ACRES					2500.00	10,000				10,000

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	EXCAVATED HILLSIDE	4	ACRES					2500.00	10,000			10,000
	Subtotal of Direct Costs											3,319,274
	SOIL STABILIZATION TOTAL											1,197,078
	OVERHEAD AND PROFIT											
	CONTRACTOR OVERHEAD (12 %)											274,339
	CONTRACTOR PROFIT (8 %)											182,893

TOTAL CAPITAL COST 3,990,466

Task No.	Task Description	Quantity	Units	Labor		Materials		Equipment		Subcontract		Total
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Amount
	YEARLY MAINTENANCE COSTS											
	SAMPLING AND ANALYSIS	40	EACH	120	4,800			40	1,600	1,000	40,000	46,400
	RAD SURVEY	4	EACH	4800	19,200							19,200
	SITE INSPECTION	24	EACH	320	7,680							7,680
	SITE MOWING OPERATIONS	1	EACH	320	320			160	160			480
	SITE REPAIRS	1	EACH	640	640			400	400	9,000	9,000	10,040

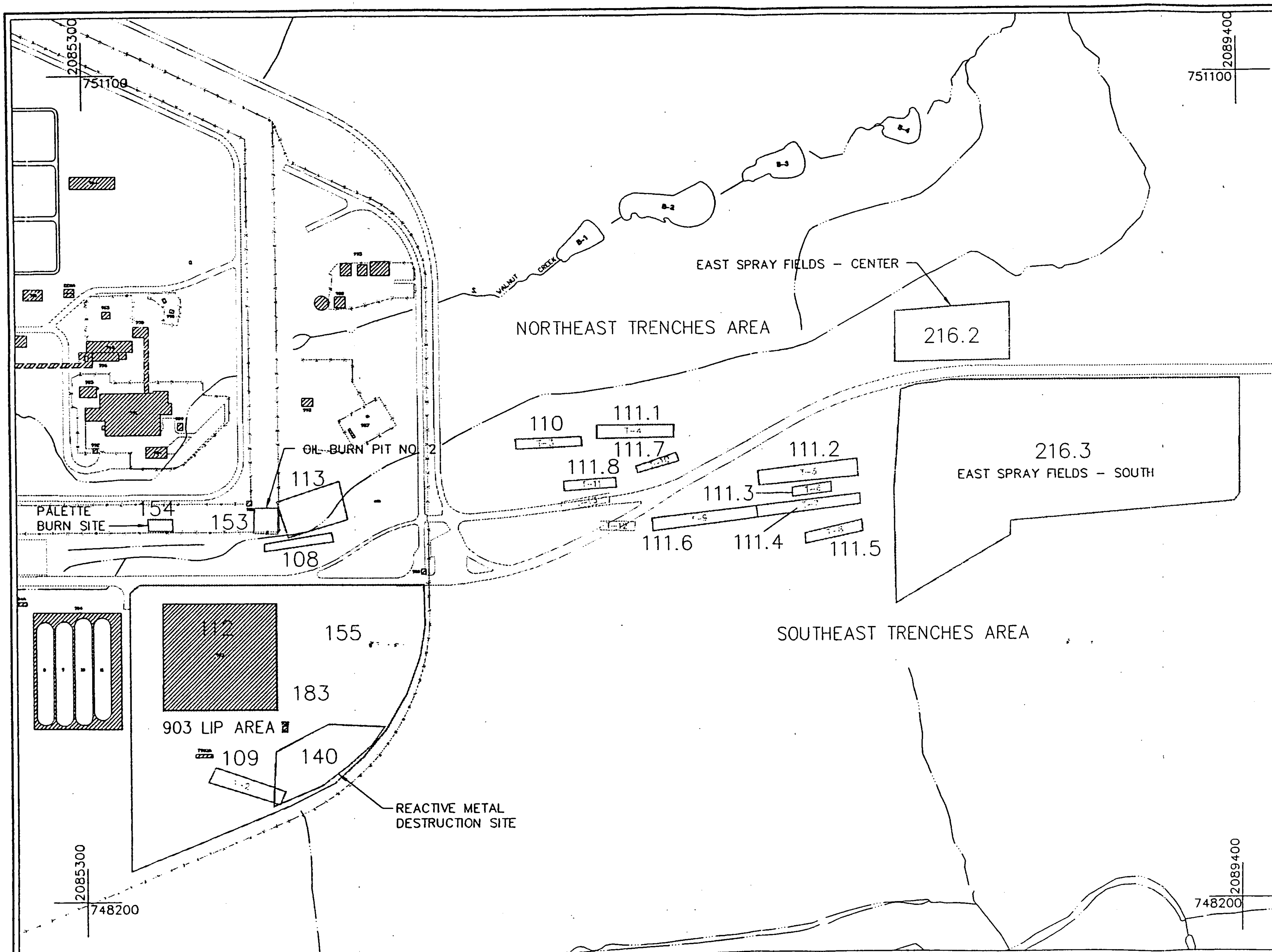
TOTAL YEARLY MAINTENANCE COST 83,800

PRESENT VALUE CALCULATION

General Information:
Capital Cost = - $3,990,466
Yearly Maintenance = - $83,800
Life of Alternative (n) = 30 years
Annual Inflation Rate (i) = 3.5 percent
Uniform Gradient Increase in Maintenance = $2,900

Present Value of Yearly Maintenance
(P/A, i, n) + (P/G, i, n)
P = A(P/A,i%,n) + G(P/G,i%,n)
= - $83,800(18.3920) - $2,900(220.1055)
= - $2,179,556

TOTAL PRESENT VALUE 6,170,000



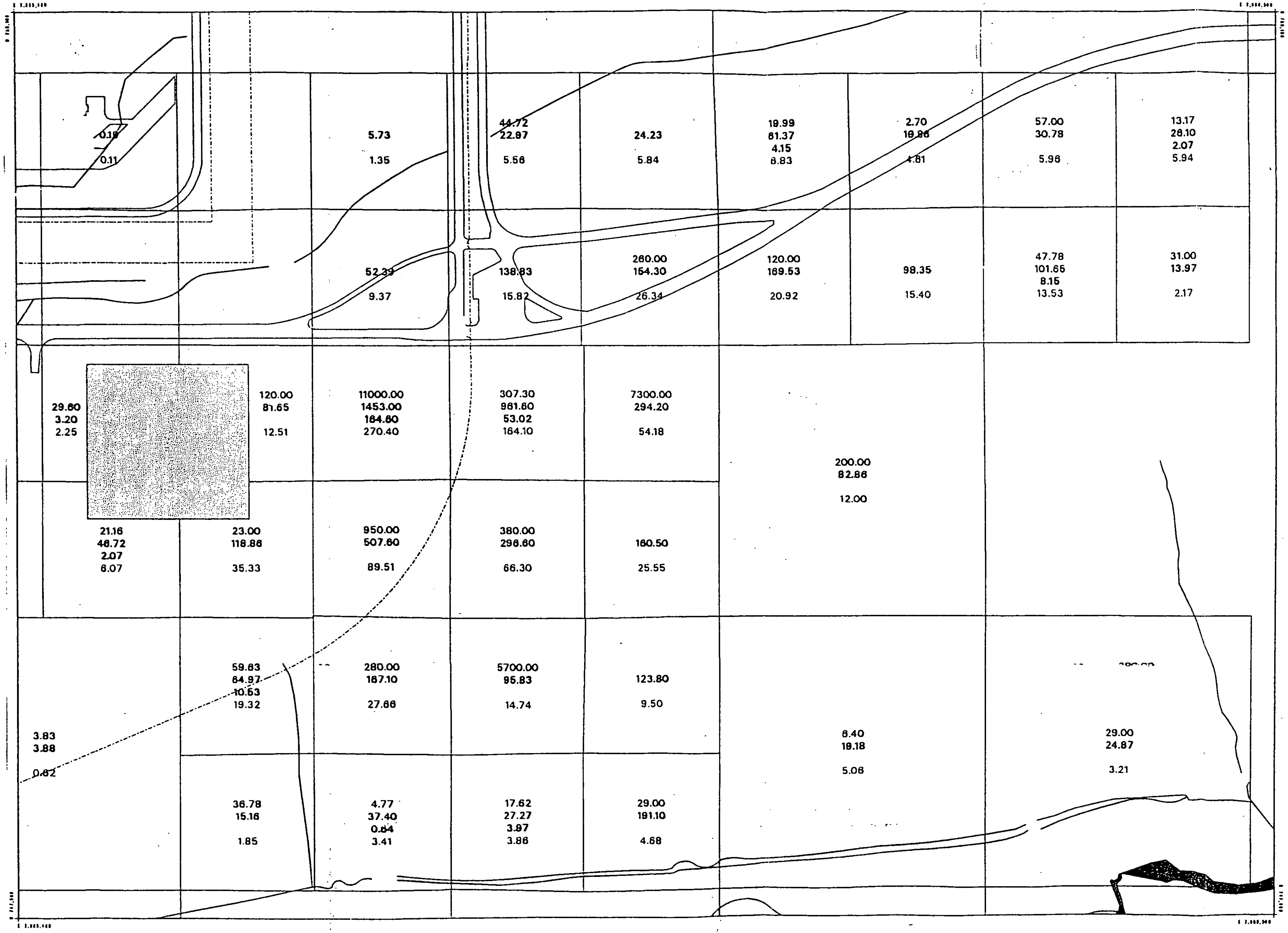
PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

Figure I. 2-2

Operable Unit No. 2
Interim Measure/ Interim Remedial Action
Map of IHSSs Within OU2

95DN1352, 09/18/95 at 13:00

Rocky Flats Surface Soil Sampling Plot Locations Around the 903 Pad



EXPLANATION

903 Pad

Lakes and ponds

Streams, ditches, or other drainage features

Fences

Paved roads

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr.
EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

1st Number = Pu 239+240 RFP Result
2nd Number = Pu 239+240 CDH Result
3rd Number = Am 241 RFP Result
4th Number = Am 241 CDH Result

Scale = 1 : 3000

100 0 200 400 Ft

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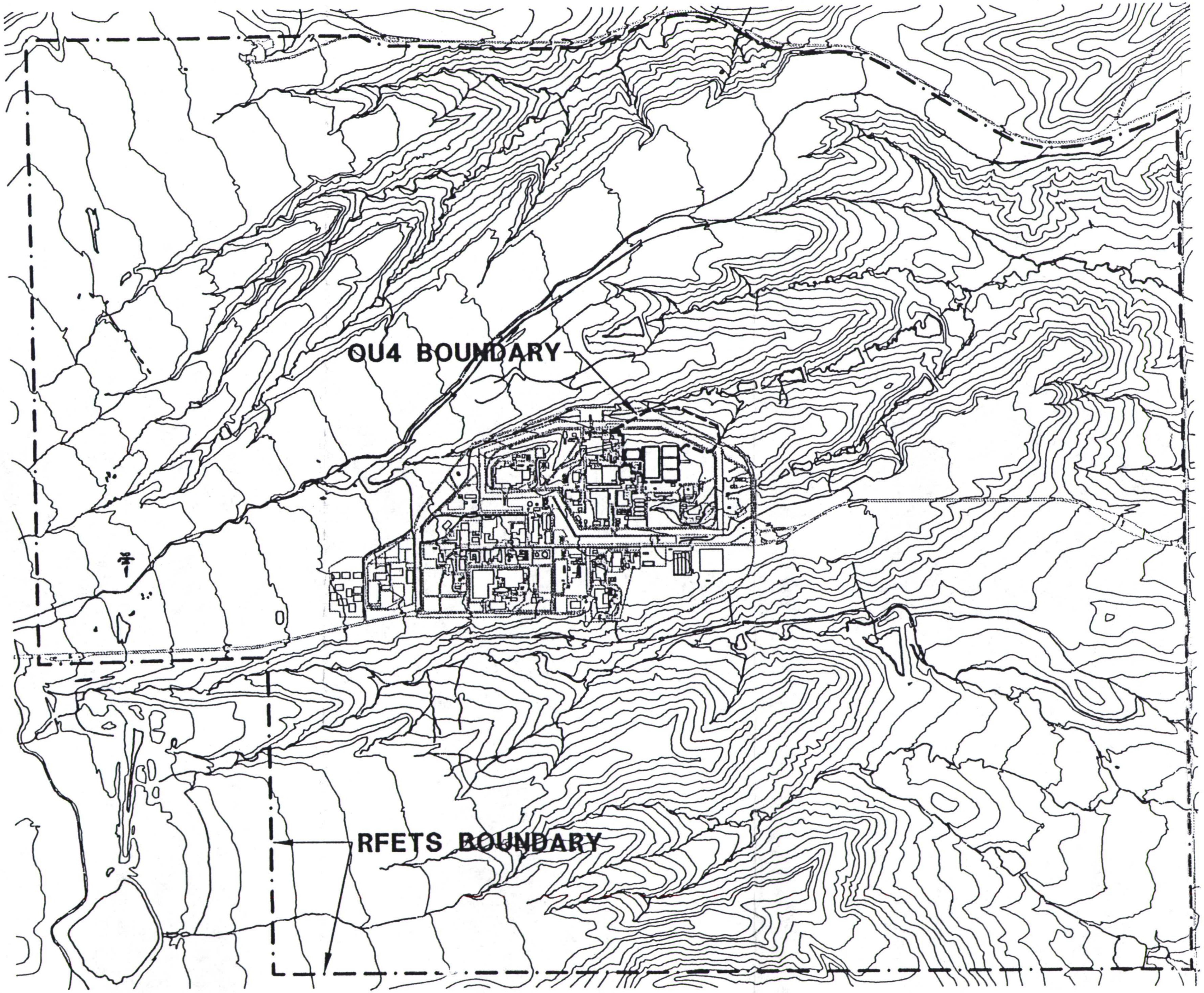
GOLDEN, COLORADO

Figure I. 5-1

Operable Unit No. 2
Surface Soil
Sampling Locations

G:\PM4\EG&G\RF11X17



CONTOUR INTERVAL = 20 FEET

0 1000 2000 3000 FEET

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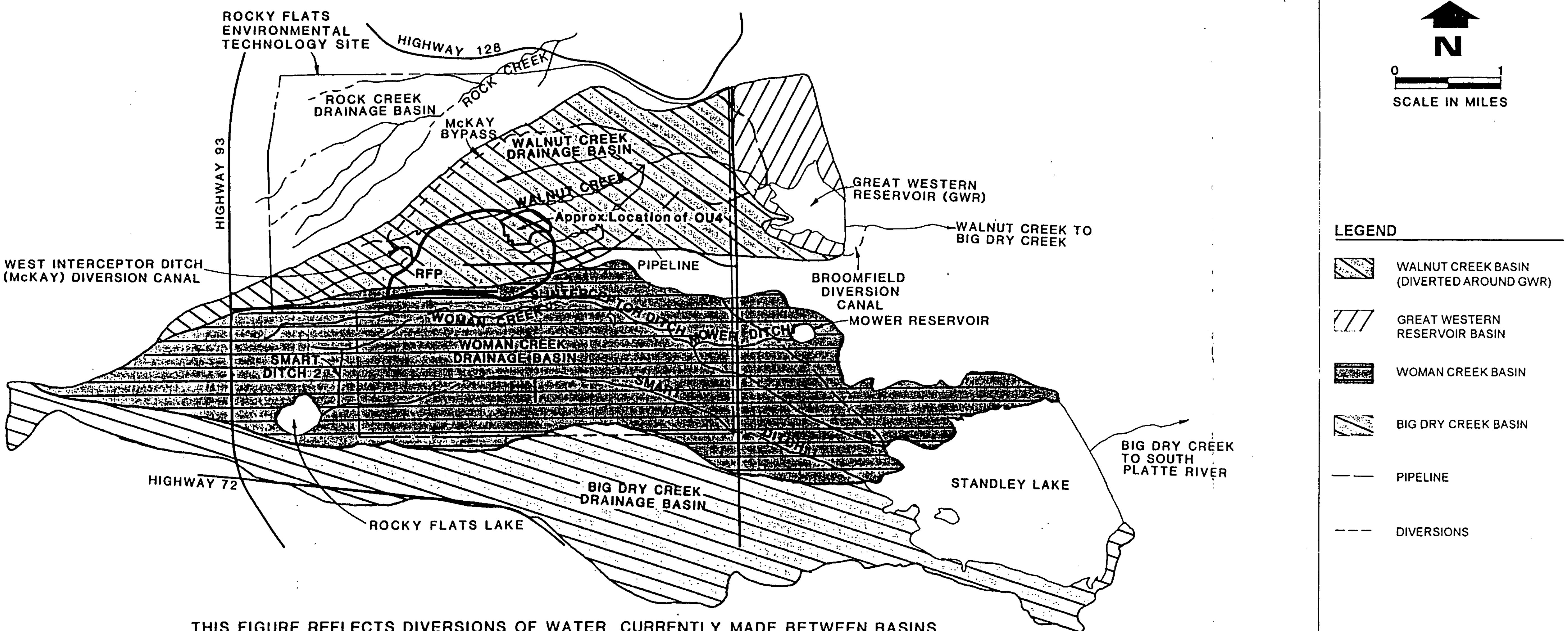
Figure A-4

Operable Unit No. 2
Topography in the Vicinity of the
Rocky Flats Environmental Technology Site

95



THIS FIGURE REFLECTS DIVERSIONS OF WATER CURRENTLY MADE BETWEEN BASINS

Source: EG&G. 1992. "Environmental Restoration Technical Support Document..."

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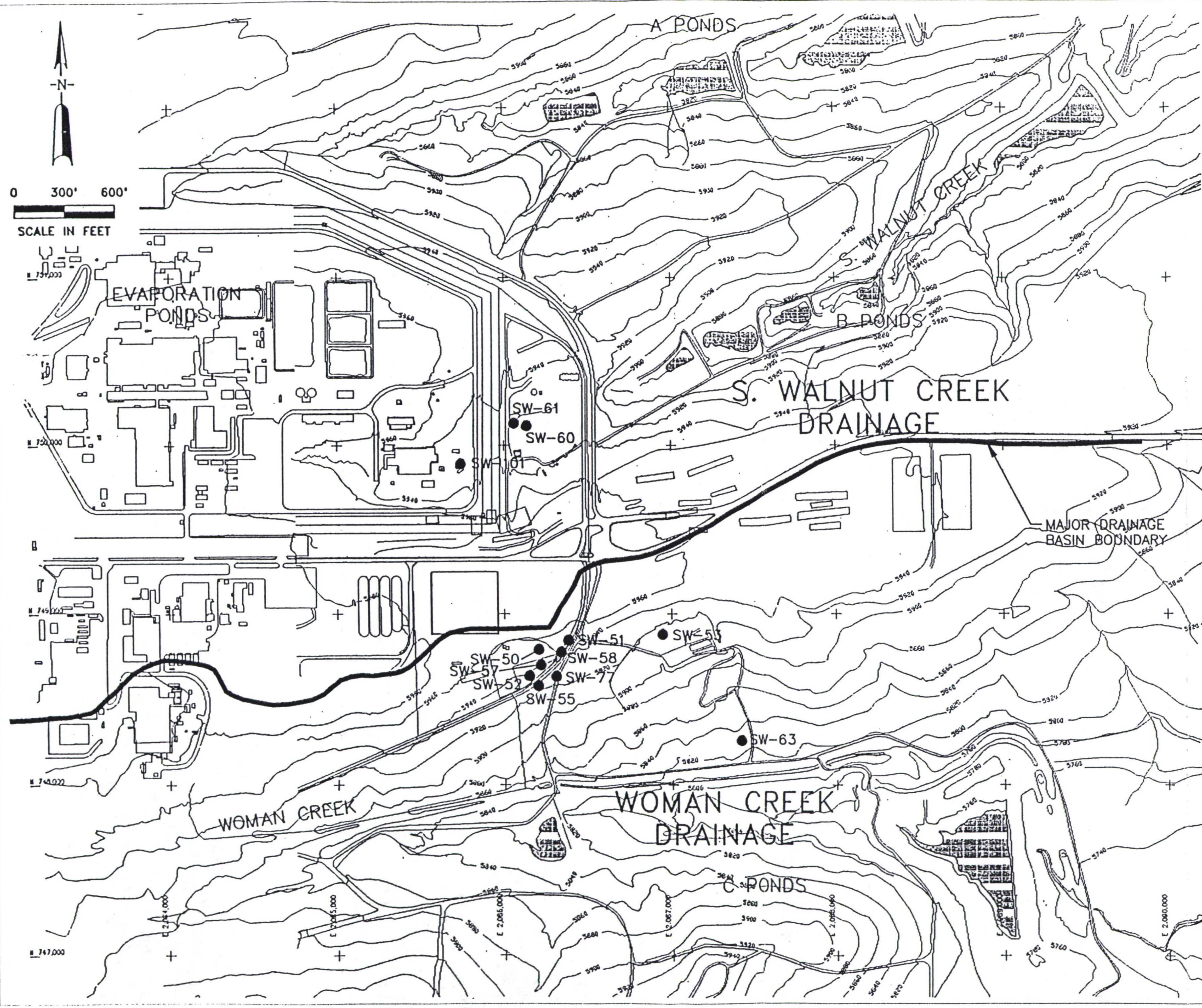
GOLDEN, COLORADO

Figure A-6

Operable Unit No. 2
Rocky Flats Environmental Technology Site Drainage Basins

99



EXPLANATION

● SW-60 SURFACE WATER SAMPLING LOCATION

SOURCE:
ROCKY FLATS PLANT DRAINAGE AND FLOOD CONTROL MASTER PLAN DOE APRIL, 1992.

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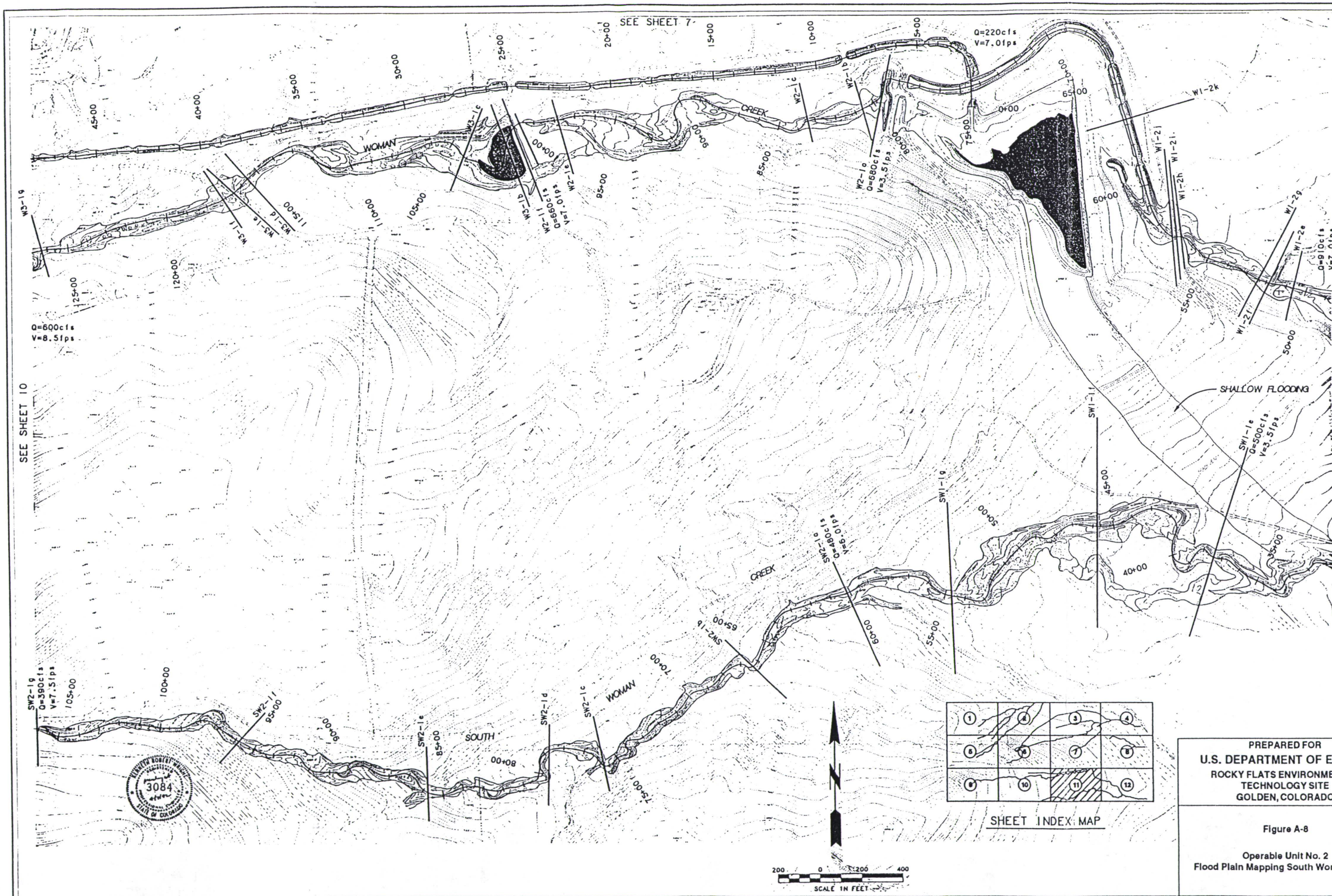
GOLDEN, COLORADO

Figure A-7

Operable Unit No. 2
Ratine Surface Water Sampling Locations In the Vicinity of the 903 Pad



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TECHNOLOGY SITE
GOLDEN, COLORADO

Figure A-8

Operable Unit No. 2
Flood Plain Mapping South Woman Creek

G:\PM4\EG&G\RF11X17

101

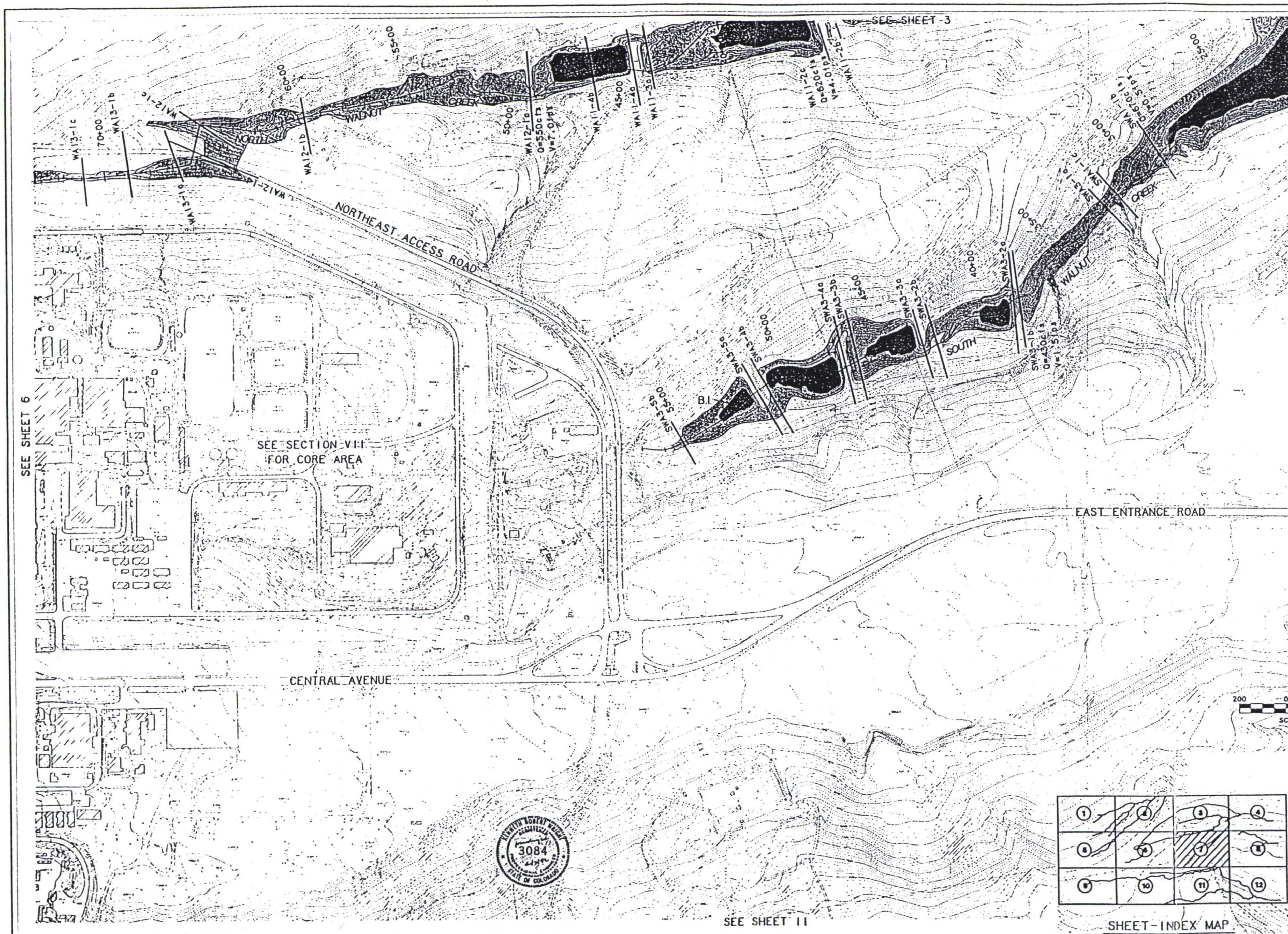

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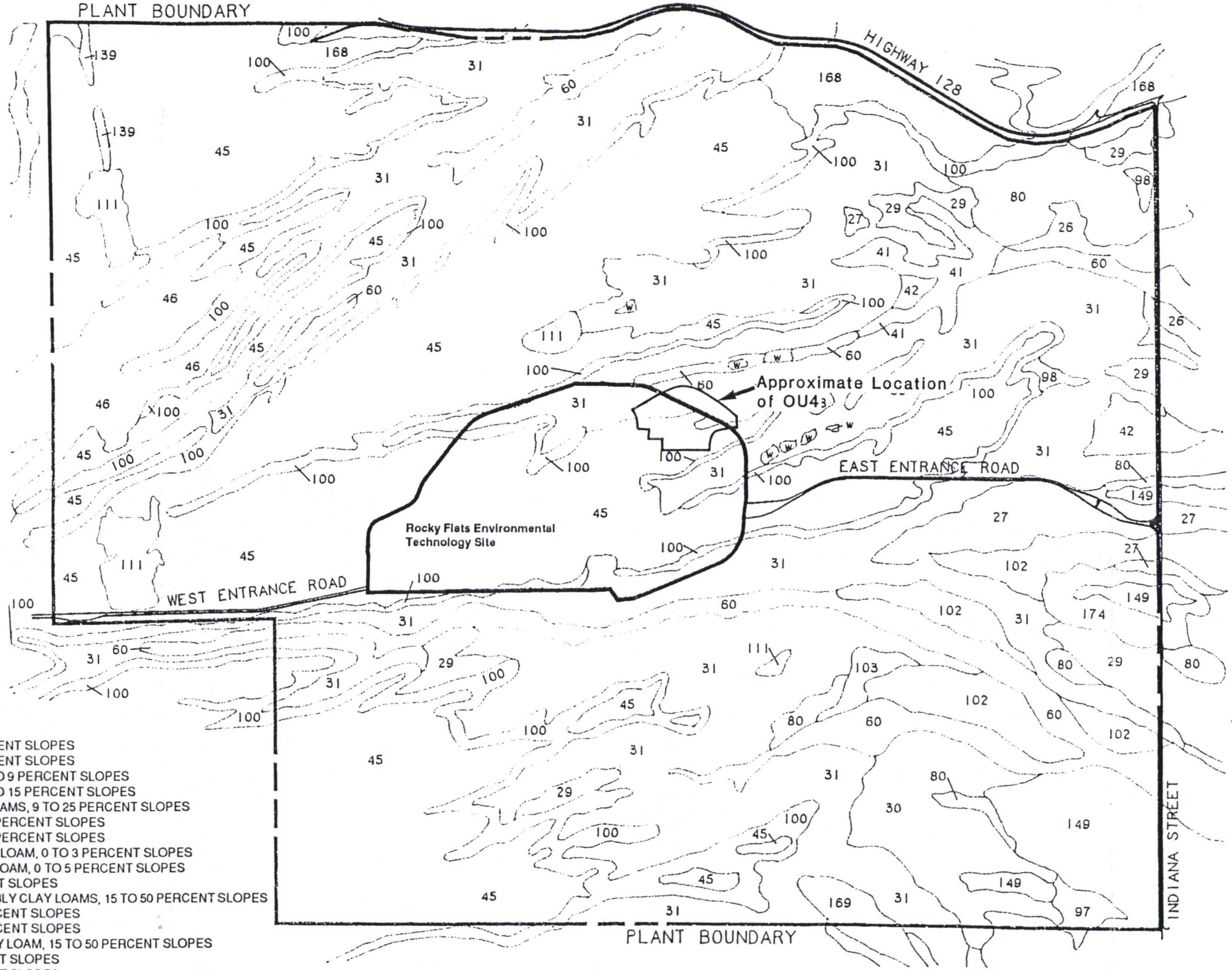
Figure A-9

Operable Unit No. 2
Flood Plain Mapping South Walnut Creek

G:\PM4\EG&G\RF11X17

103



SOIL LEGEND

26 DENVER CLAY LOAM, 2 TO 5 PERCENT SLOPES
27 DENVER CLAY LOAM, 5 TO 9 PERCENT SLOPES
29 DENVER-KUTCH CLAY LOAMS, 5 TO 9 PERCENT SLOPES
30 DENVER-KUTCH CLAY LOAMS, 9 TO 15 PERCENT SLOPES
31 DENVER-KUTCH-MIDWAY CLAY LOAMS, 9 TO 25 PERCENT SLOPES
41 ENGLEWOOD CLAY LOAM, 0 TO 2 PERCENT SLOPES
42 ENGLEWOOD CLAY LOAM, 2 TO 5 PERCENT SLOPES
45 FLATIRONS VERY COBBLY SANDY LOAM, 0 TO 3 PERCENT SLOPES
46 FLATIRONS VERY STONY SANDY LOAM, 0 TO 5 PERCENT SLOPES
60 HAVERSON LOAM, 0 TO 3 PERCENT SLOPES
80 LEYDEN-PRIMEN-STANDLEY COBBLY CLAY LOAMS, 15 TO 50 PERCENT SLOPES
97 McCLAVE CLAY LOAM, 0 TO 3 PERCENT SLOPES
98 MIDWAY CLAY LOAM, 9 TO 30 PERCENT SLOPES
100 NEDERLAND VERY COBBLY SANDY LOAM, 15 TO 50 PERCENT SLOPES
102 NUNN CLAY LOAM, 2 TO 5 PERCENT SLOPES
103 NUNN CLAY LOAM, 2 TO 5 PERCENT SLOPES
111 PITS, GRAVEL
139 ROCK OUTCROP, SEDIMENTARY
149 STANDLEY-NUNN GRAVELLY CLAY LOAMS, 0 TO 5 PERCENT SLOPES
168 VALMONT-CLAY LOAM, 0 TO 3 PERCENT SLOPES
169 VELDKAMP-NEDERLAND VERY COBBLY SANDY LOAMS, 0 TO 3 PERCENT SLOPES
174 WILLOMANN-LEYDEN COBBLY-LOAMS, 9 TO 30 PERCENT SLOPES
w SURFACE WATER CONTROL STRUCTURES (RETENTION BASINS)

Source: ASI. 1991. "The SEPs ITS Ground Water Management Study..."

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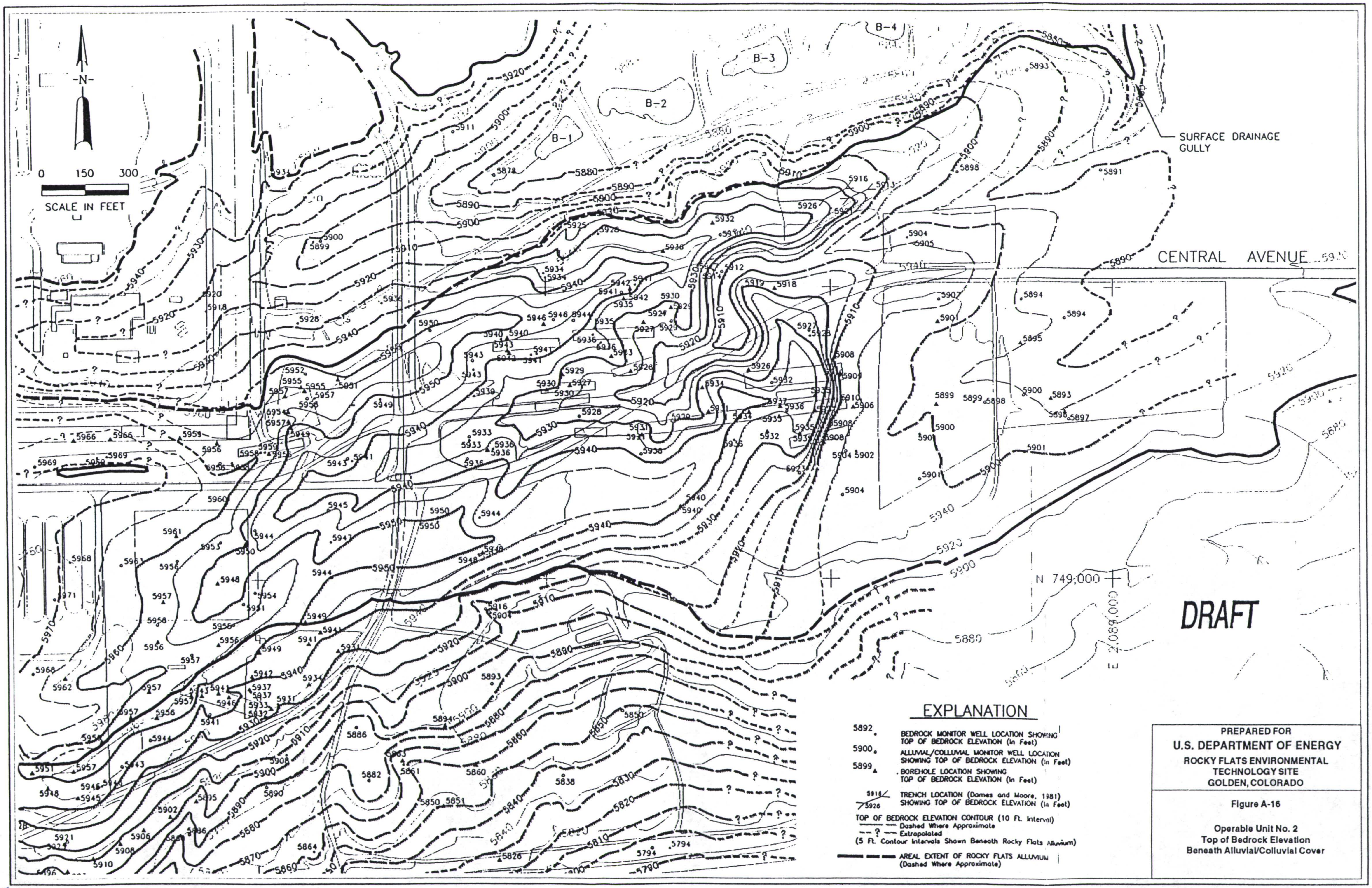
Figure A-10

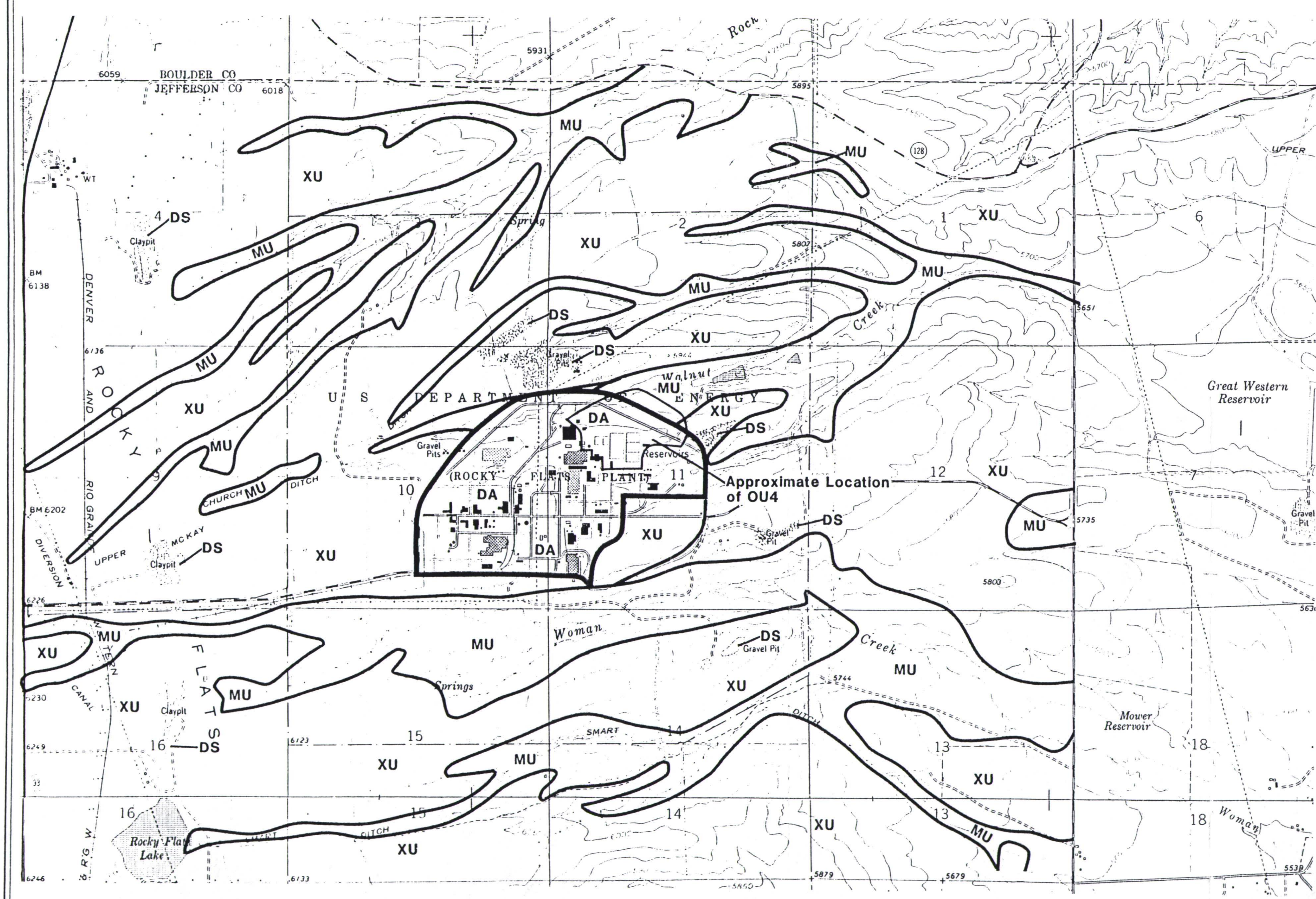
Operable Unit No. 2
Soil Types in the Vicinity of the Rocky Flats Environmental Technology Site

105 d11x17



G:\PM4\EG&G\RF11X17

115



LEGEND

- **XU** Xeric Upland Habitats
- **MU** Mesic Upland Habitats
- **DS** Highly Disturbed Sites
- **DA** Developed Areas

0 2000
FEET

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Figure A-17

Operable Unit No. 2
Upland Habitats at the
Rocky Flats Environmental Technology Site

Source: ASI. 1991. "The SEPs ITS Ground Water Management Study..."

117 tf11x17

OU2 DOSE BASED PRGS based on BRA for 15 mrem/yr goal

NOTE: THIS ANALYSIS IS BASED ON EXISTING PRG EQUATIONS AND DOES NOT COMPLY WITH DOE ORDER 5400.5 METHODOLOGY. THIS CALCULATION IS BASED ON EPA RAGs EQUATIONS USED FOR DETERMINING ACTION LEVEL FOR CHEMICALS.

RADIOLOGICAL PROGRAM
TITLE: 15 mrem Soil Conc. OU-2
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VERIFIED RJm DATE 8/22/95

Rev. 2

ASSUMPTIONS

	CT VALUE					RME VALUE						
Row	VARIABLE DESCRIPTION	UNITS		OFFICE WORKER	OPEN SPACE ADULT/CHILD	VARIABLE DESCRIPTION	UNITS		OFFICE WORKER	OPEN SPACE ADULT/CHILD		
9	EXPOSURE FREQUENCY	DAYS/YR	EF	219	10	EXPOSURE FREQUENCY	DAYS/YR	EF	250	25		
10	EXPOSURE TIME	hr/day	ET	7.2	1.5	EXPOSURE TIME	hr/day	ET	8	5		
11	DAILY INHALATION RATE	m3/hr	IRa	0.63	0.83	DAILY INDOOR INHALATION RATE	m3/hr	IRa	0.83	1.4	6.64	7
12	EXPOSURE DURATION	YR	ED	1	1	EXPOSURE DURATION	YR	ED	1	1	"=L11*L10	"=M11*M10"
13	PARTICULATE EMISSION FACTOR	m3/kg	PEF	7.20E+07	7.20E+07	PARTICULATE EMISSION FACTOR	m3/kg	PEF	7.20E+07	7.20E+07		
14	SOIL INGESTION RATE	mg/DAY	IF	5	88	SOIL INGESTION RATE	mg/DAY	IF	50	60		
15	FRACTION SOIL FROM CONTAMINATED SOURCE		FSCS	1	1	FRACTION SOIL FROM CONTAMINATED SOURCE		FSCS	1	1		
16	GAMMA SHIELDING FACTOR		Se	0.5	0.2	GAMMA SHIELDING FACTOR		Se	0.2	0		
17	GAMMA EXPOSURE FACTOR		Te	1	1	GAMMA EXPOSURE FACTOR		Te	1	1		
18	DOSE GOAL	mrem/YR	dDG	15	15	DOSE GOAL	mrem/YR	dDG	15	15		
19	RESPIRABLE FRACTION		RF	1	1	RESPIRABLE FRACTION		RF	1	1		
20	RESPIRATORY DEPOSITION FACTOR		RDF	0.851	0.85	RESPIRATORY DEPOSITION FACTOR		RDF	1	1		
21	INGESTION RATE SURFACE WATER/WADING	L/hr	IRW	0	0	INGESTION RATE SURFACE WATER/WADING	L/hr	IRW	0	0		
22	WADING/SURFACE RATE	hr/visit OR hr/day	WR	0	0.5	WADING RATE/SURFACE WATER EXP	hr/visit OR hr/day	WR	0	1		
23	WADING/SURFACE EXPOSURE FREQUENCY	visit/year OR days/yr	WRF	0	5	WADING/SURFACE EXPOSURE FREQUENCY	visit/year OR days/yr	WRF	0	15		
24	WATER TO SOIL CONTAMINATION RATIO		WSCR	1	1	WATER TO SOIL CONTAMINATION RATIO		WSCR	1	1		

RADIONUCLIDE	INHALATION EPA DOSE FACTOR (Sv/Bq)	INGESTION EPA DOSE FACTOR (Sv/Bq)	INHALATION EPA DOSE FACTOR (rem/uCi)	INGESTION EPA DOSE FACTOR (rem/uCi)
Pu-239	8.33E-05	1.40E-08	3.08E+02	5.18E-02
Pu-240	8.33E-05	1.40E-08	3.08E+02	5.18E-02
Am-241	1.20E-04	9.84E-07	4.44E+02	3.64E+00
			"=S21*3700000"	
				"=T21*3700000"

THIS NUMBER WOULD NORMALLY VARY AS A FUNCTION OF WORK ACTIVITIES AND SITE CONDITIONS, TYPICALLY DONE USING RESUSPENSION FACTORS.

THE PEF WAS CALCULATED BASED ON THE ASSUMED SOIL CONCENTRATION AND THE AIR CONCENTRATION BASED ON MODELING DISCUSSED IN THE BRA

EFFECTIVE DOSE EQUIVALENT FACTOR (50 YEARS) (rem/uCi)

RADIONUCLIDE	Pu-239	Pu-240	U-234	U-238	Th-234	Am-241	U-235	Th-231
INHALATION	3.08E+02	3.08E+02	1.30E+02	120	0.00E+00	4.44E+02	1.20E+02	0.00E+00
INGESTION	5.18E-02	5.18E-02	2.60E-02	2.30E-01	0.00E+00	3.64E+00	2.50E-01	0.00E+00
						(rem/yr)/(pCi/g)		
EXTERNAL SURFACE	3.48E-06	7.54E-06	7.42E-06	9.89E-05	NA	2.75E-04	1.75E-03	NA

NOTE, Pu AND Am INHALATION AND INGESTION DOSE FACTORS ARE BASED ON "LIMITING VALUES OF INTAKE AND AIR CONCENTRATION AND DOSE CONVERSION FACTOR FOR INHALATION, SUBMERSION, AND INGESTION (FEDERAL GUIDANCE REPORT NO. 11). SINCE THE OTHER RADIONUCLIDES ARE NOT ADDRESSED IN THE BRA THEY ARE STILL BASED ON DOE/EH-0071. NOTE, THE DIFFERENCES ARE NOT ACTUALLY SIGNIFICANT.

UPTAKE CHARACTERISTICS

INHALATION	INGESTION	ELEMENT
Y	1.00E-05	PLUTONIUM
W	1.00E-03	AMERICIUM

122

OU2 DOSE BASED PRGS based on BRA for 15 mrem/yr goal

NOTE: THIS ANALYSIS IS BASED ON EXISTING PRG EQUATIONS AND DOES NOT COMPLY WITH DOE ORDER 5400.5 METHODOLOGY. THIS CALCULATION IS BASED ON EPA RAGs EQUATIONS USED FOR DETERMINING ACTION LEVEL FOR CHEMICALS.

Row	A–B	C	D	E	G–H	I	J	K
45						BASED ON RME VALUES		
46		K1	K2	KX		K1	K2	KX
47	PRG CALCULTION	"=F$9*F$10*F$11*F$19*F$20*F$12/F$13"	"=F$12*F$9*0.000001*F$14	"=F$12*(1-F$16)*F$17*F10/24*1000*F9/365		"=L$9*L$10*L$11*L$19*L$20*L$12/L$13"	"=L$12*L$9*0.00001*L$14"	"=L12*(1-L16)*L17*L10/24*1000*L9/365"
48	BASED ON CT VALUES							
49	OFFICER WORKER	1.17E-05	1.10E-03	9.00E+01	OFFICER WORKER	2.31E-05	1.25E-02	1.83E+02
50	OPEN SPACE	1.47E-07	8.60E-04	1.37E+00	OPEN SPACE	2.43E-06	1.50E-03	1.43E+01

PRG CALCULATION FOR CT

RADIONUCLIDE			OFFICE WORKER			OPEN SPACE
Pu-239	3.68E-03	3.13E-04	3.76E+03	8.98E-05	4.76E-06	1.59E+05
Pu-240	3.68E-03	6.79E-04	3.44E+03	8.98E-05	1.03E-05	1.50E+05
U-234	1.55E-03	6.68E-04	6.75E+03	4.15E-05	1.02E-05	2.90E+05
U-235	1.68E-03	1.57E-01	9.43E+01	2.33E-04	2.40E-03	5.71E+03
U-238	1.66E-03	8.90E-03	1.42E+03	2.15E-04	1.35E-04	4.28E+04
Am-241	9.20E-03	2.48E-02	4.42E+02	3.20E-03	3.77E-04	4.20E+03

PRG CALCULATION FOR RME

RADIONUCLIDE			OFFICE WORKER			OPEN SPACE
Pu-239	7.75E-03	6.35E-04	1.79E+03	8.27E-04	4.96E-05	1.71E+04
Pu-240	7.75E-03	1.38E-03	1.64E+03	8.27E-04	1.08E-04	1.61E+04
U-234	3.32E-03	1.36E-03	3.21E+03	3.55E-04	1.06E-04	3.25E+04
U-235	5.89E-03	3.19E-01	4.81E+01	6.67E-04	2.50E-02	5.85E+02
U-238	5.64E-03	1.81E-02	6.33E+02	6.37E-04	1.41E-03	7.33E+03
Am-241	5.57E-02	5.02E-02	1.42E+02	6.54E-03	3.93E-03	1.43E+03

The ingestion of surface water is not included in the evaluation since, based on the Baseline Risk Assessment it is not a significant contributor to the dose.

THE GRAYTONE ROW SECTION'S EQUATIONS ARE SHOWN BELOW.

"=($I49*$D$30+($J49*L15)*D31)" "=($I50*$D$30+($J50*M15)*D31)"

"=($C49*$D$30+($D49*F15)*D31)" "=($C50*$D$30+($D50*G15)*D31)" "=$K49*$D$34" "=$K50*D34"

"=$E49*$D$34" "=$E50*D34" "=(L18)/($M56+$N56)" "=(M18)/($P56+$Q56)"

"=(F18)/($E56+$F56)" "=(G18)/($H56+$I56)"

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	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Pu-239		3.78E-02		3.48E-06		ASSUMES THAT THE TOP 5 cm OF SOIL ARE LOCATED ON THE SURFACE AND THERE IS NO CONTRIBTION FROM SOIL BELOW THIS DEPTH.					
2		Pu-240		8.20E-02		7.54E-06			Soil Depth (cm)	Soil Density (pCi/g)	"=I40*j40		
3		U-234		8.07E-02		7.42E-06			5	1.84	9.20E-05		
4		U-235	1.91	1.90E+01		1.75E-03							
5		U-238	1.01	1.07E+00		9.89E-05							
6		Am-241		2.99		2.75E-04							
7													
8			THORIUM PROGENY	"=17.1+C41"		"=D39*0.000085"			DFa(rem*g/pCi/yr)=DFa (mrem*sqm/uCi/yr)*1uCi/1E6pCi*d(cm)*p(g/cc)*1E4sqcm/sqm*1rem/1e3mrem				
9													
10		DOSE FACTORS BASE ON VALUES IN DOE/EH-0070 FOR AREAL CONTAMINATION.											
11													
12													
13													
14													
15													

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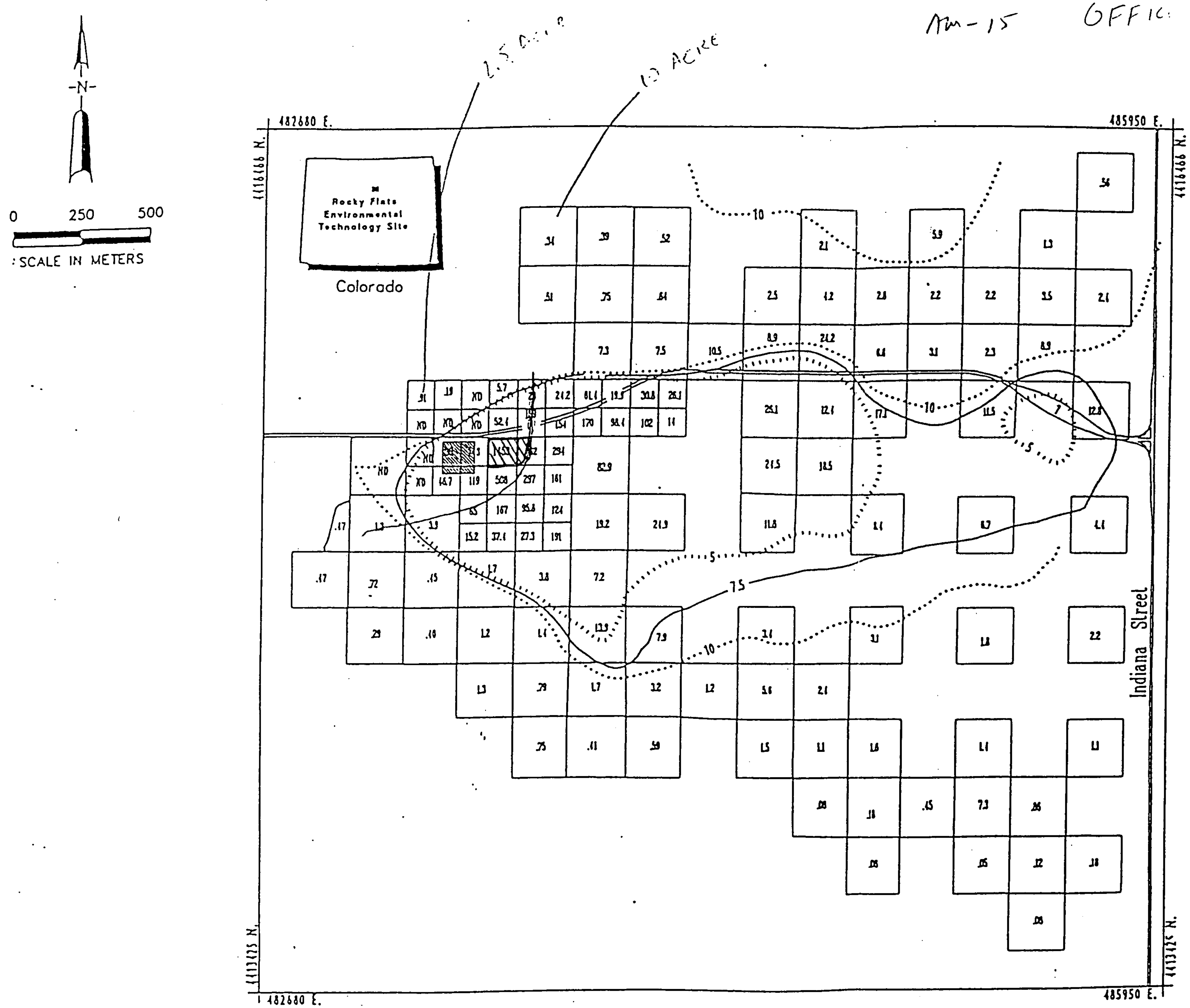
Am-15 OFFICE WORKER

	15 mrem Office worker	Open space
Pu-239	1600	15,000
Am-241	140	1400



EXPLANATION

82.9 SAMPLING PLOT WITH OBSERVED VALUE (IN pCi/g) IN THE CENTER

Remediation Area

5 / 7.5 / 10 — 7.5 pCi/g CONTOUR OF Pu-239/240 WITH 90% EMPIRICAL CONFIDENCE LIMITS

903 PAD

PRG = 1,389

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

Figure 2.1

Areal Extent of Remediation to a 1.0E-4 Target Risk Level Based on a PRG Analysis

Source: Phase II RFI/RI Report 903 Pad, Mound, East Trenches area Operable Unit No. 2

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ATTACHMENT 1

AM-15 (office worker)

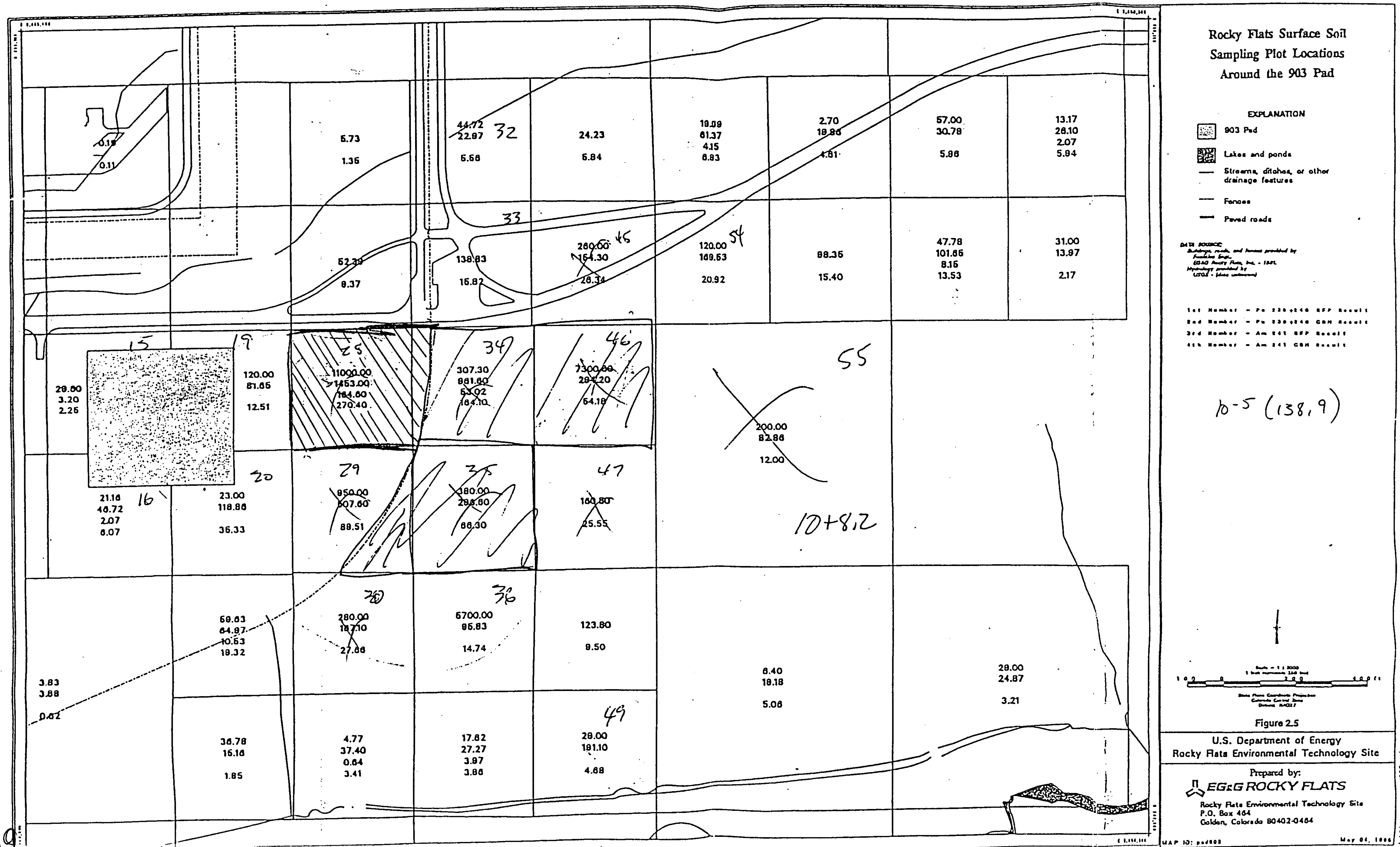

Figure 2.5

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